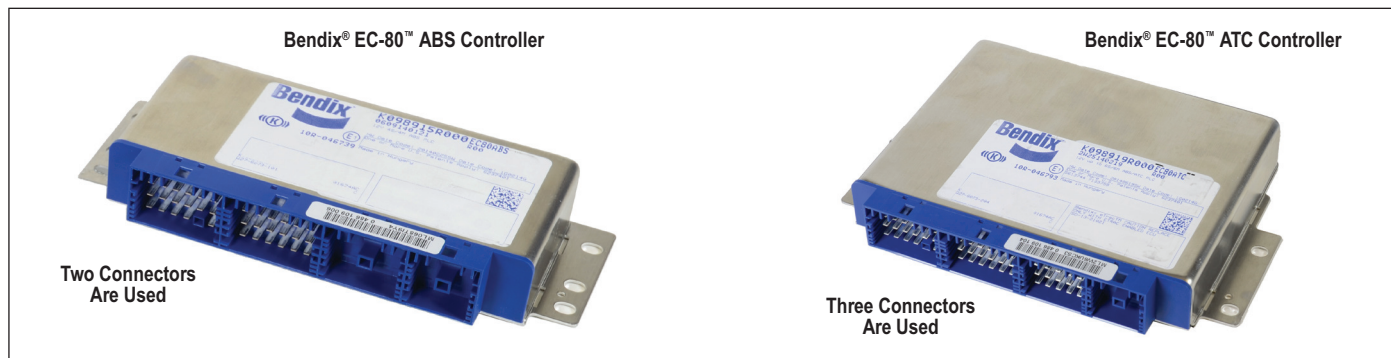




Service Data

SD-13-4983

Bendix® EC-80™ ABS / ATC Controllers



See SD-13-21021 for the Bendix® eTrac™ Automated Air Suspension Transfer System

Bendix® EC-80™ ESP(+) Controllers will be featured in SD-13-4986.

INTRODUCTION

Bendix® EC-80™ ABS and ATC controllers are members of a family of electronic **Antilock Braking System (ABS)** devices designed to help improve the braking characteristics of air braked vehicles - including heavy- and medium-duty buses, trucks, and tractors. ABS controllers are also known as **Electronic Control Units (ECUs)**.

Bendix® ABS uses wheel speed sensors, ABS modulator valves, and an ECU to control either four or six wheels of a vehicle. By monitoring individual wheel turning motion during braking, and adjusting or pulsing the brake pressure at each wheel, the Bendix EC-80 controller is able to optimize slip between the tire and the road surface. When excessive wheel slip, or wheel lock-up is detected, the Bendix EC-80 controller will activate the Pressure Modulator Valves to simulate a driver pumping the brakes. However, the Bendix EC-80 controller is able to pump the brakes on individual wheels (or pairs of wheels) independently, and with greater speed and accuracy than a driver.

In addition to the ABS function, the ATC version of the Bendix EC-80 controller provides an **Automatic Traction Control (ATC)** feature. Bendix® ATC can improve vehicle traction during acceleration, plus lateral stability while driving through curves. ATC utilizes **Engine Torque Limiting (ETL)** where the ECU communicates with the engine's controller and/or **Differential Braking (DB)** where individual wheel brake applications are used to improve vehicle traction.

Bendix EC-80 ATC controllers also have the capability to provide a **Hill Start Assist (HSA)** feature. HSA interfaces

FIGURE 1 - BENDIX® EC-80™ ABS AND ATC CONTROLLERS

WARNING

The driver is always responsible for the control and safe operation of the vehicle at all times. The Bendix® ABS system does not replace the need for a skilled, alert professional driver, reacting appropriately and in a timely manner, and using safe driving practices.

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GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- ▲ Park the vehicle on a level surface, apply the parking brakes and always block the wheels. Always wear personal protection equipment.
- ▲ Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically-charged components.
- ▲ Do not attempt to install, remove, disassemble or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
- ▲ If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, or a Bendix® AD-9si™ air dryer, be sure to drain the purge reservoir.
- ▲ Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
- ▲ Never exceed manufacturer's recommended pressures.
- ▲ Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
- ▲ Use only genuine Bendix® brand replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
- ▲ Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
- ▲ Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.
- ▲ For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.
- ▲ The power **MUST** be temporarily disconnected from the radar sensor whenever any tests **USING A DYNAMOMETER** are conducted on a Bendix® Wingman® Advanced™-equipped vehicle.
- ▲ You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.

between the transmission and braking system to help the driver prevent the vehicle from rolling backwards when moving forward from a stationary position on steep inclines. Bendix® EC-80™ ATC controllers have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

COMPONENTS/ECU MOUNTING

The Bendix EC-80 controller's ABS function uses:

- Bendix® WS-24™ wheel speed sensors (4 or 6, depending on ECU and configuration). Each sensor is installed with a Bendix® Sensor Clamping Sleeve
- Bendix® M-32™ / M-32QR™ / M-40X™ Pressure Modulator Valves (4, 5, or 6 depending on ECU and configuration)
- Dash-mounted tractor ABS indicator lamp
- Service brake relay valve
- Dash-mounted trailer ABS indicator lamp (used on all towing vehicles manufactured after March 1, 2001)
- Optional blink code activation switch
- Optional ABS off-road switch. (Off-road feature is not available on all ECUs - See Chart 1.)

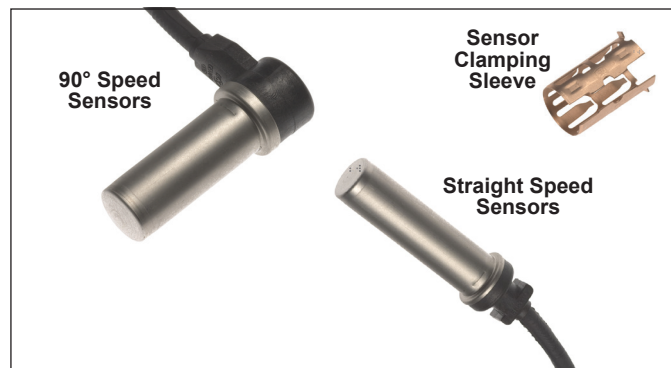


FIGURE 2 - BENDIX® WS-24™ WHEEL SPEED SENSORS

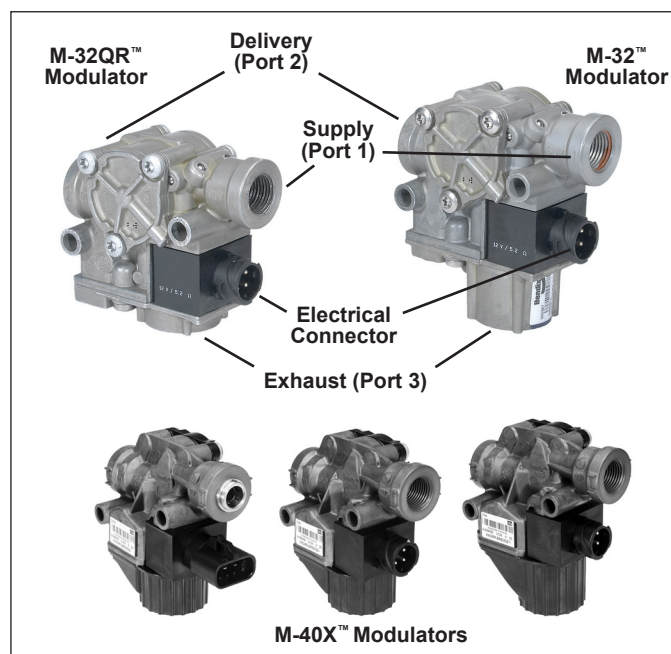


FIGURE 3 - BENDIX® M-32™ AND M-40X™ MODULATORS

The Automatic Traction Control (ATC) function uses the following additional components:

- Traction control valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ATC status/indicator lamp
- J1939 serial communication to engine control module
- Stop lamp switch input (may be provided using the ECU hardware input or J1939)
- Optional ATC off-road switch

The Hill Start (HSA) function uses the following components:

- Traction Control Valve (TCV)
- Dash-mounted HSA status/indicator lamp
- Dash-mounted Enable/Disable switch
- RV-3 Pressure Reducing Valve
- DC-4 Double Check valve

ECU MOUNTING

Bendix® EC-80™ controllers are cab-mounted. They are not protected against moisture and must be mounted in an environmentally protected location.

All wire harness connectors must be properly seated. The use of secondary locks is strongly recommended.



All unused ECU connectors must be covered and receive any necessary protection from moisture, etc.

ECUs utilize connectors from the AMP MCP 2.8 product family.

HARDWARE CONFIGURATIONS

Bendix® EC-80™ ABS Controllers

Bendix EC-80 ABS controllers support four sensor/four modulator (4S/4M) applications. Certain models support Power Line Carrier (PLC) communications, with all models supporting 12 volt installations. *See Chart 1 for more details.*

Bendix EC-80 ATC Controllers

Bendix EC-80 ATC controllers support applications up to six sensor/six modulator (6S/6M) installations with ATC and drag torque control. They can support HSA functions. All 12 volt models support Power Line Carrier (PLC). 24 volt models do not support PLC. *See Chart 1 for more details.*

BENDIX EC-80 CONTROLLERS WITH PLC

Since March 1, 2001, all towing vehicles must have an in-cab trailer ABS indicator lamp. Trailers transmit the status of the trailer ABS over the power line (the blue wire of the J560 connector) to the tractor using a PLC signal. *See Figures 4 and 5.*

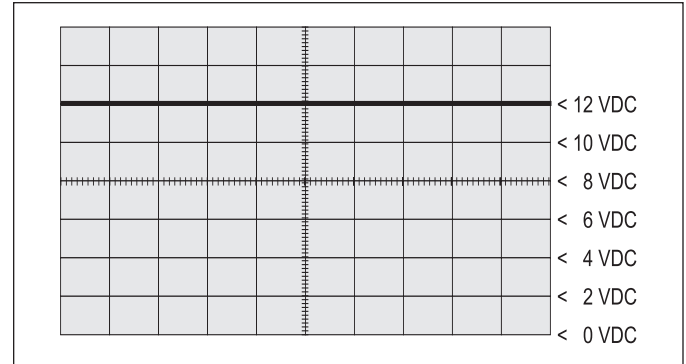


FIGURE 4 - POWER LINE WITHOUT PLC SIGNAL

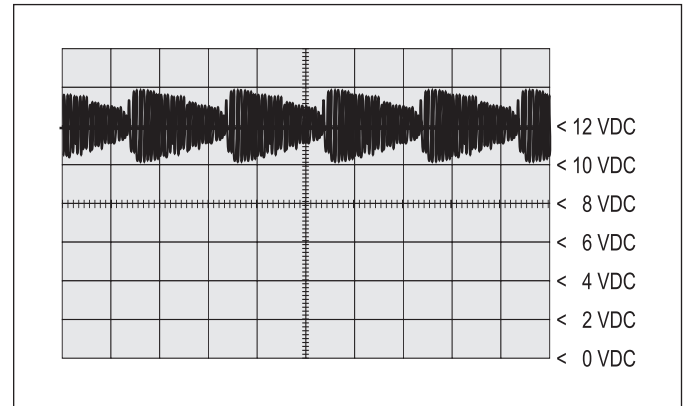


FIGURE 5 - POWER LINE WITH PLC SIGNAL

Typically the signal is broadcast by the trailer ABS ECU. The application of PLC technology for the heavy vehicle industry is known as "PLC4Trucks." The Bendix EC-80

ECU	Mounting	Input Voltage	Sensors	PMVs	ATC	Blink Codes	Serial Communication	PLC	ABS Off-Road	ATC Off-Road	Retarder Relay
							J1939				
Bendix EC-80 ABS controller	Cab	12	4	4	-	✓	✓	-	-	-	✓
Bendix EC-80 ABS PLC controller	Cab	12	4	4	-	✓	✓	✓	-	-	✓
Bendix EC-80 ATC controller	Cab	12	4/6	4/5/6	✓	✓	✓	✓	✓	✓	✓
Bendix EC-80 ATC controller	Cab	24	4/6	4/5/6	✓	✓	✓	-	✓	✓	✓

CHART 1 - BENDIX® EC-80™ CONTROLLERS AVAILABLE

PLC controller and the Bendix EC-80 ATC controller (12 volt versions) support PLC communications in accordance with SAE J2497.

Identifying a Bendix EC-80 Controller with PLC

Refer to the information panel on the ECU label to see if the controller provides PLC.

An oscilloscope can be used to measure or identify the presence of a PLC signal on the power line. The PLC signal is an amplitude and frequency-modulated signal. Depending on the filtering and load on the power line, the PLC signal amplitude can range from 5.0 mVp-p to 7.0 Vp-p. Suggested oscilloscope settings are AC coupling, 1 volt/div, 100 µsec/div. The signal should be measured at the ignition power input of the Bendix EC-80 controller.

Note: An ABS trailer equipped with PLC or a PLC diagnostic tool must be connected to the vehicle in order to generate a PLC signal on the power line.

To confirm if a specific ECU uses PLC or not, see the Controller Specifications box below.

BENDIX EC-80 CONTROLLER INPUTS

Battery and Ignition Inputs

The ECU operates at a nominal supply voltage of 12 or 24 volts, depending on the ECU. The battery input is connected through a 30 amp fuse directly to the battery.

The ignition input is applied by the ignition switch through a 5 amp fuse.

Ground Input

The Bendix EC-80 controller supports one ground input. See pages 35-37 for electrical system schematics.

ABS Indicator Lamp Ground Input

Bendix EC-80 ECUs require a second ground input (X1-12) for the ABS indicator lamp. The X1 wire harness connector contains an ABS indicator lamp interlock (X1-15), which shorts the ABS indicator lamp circuit (X1-18) to ground if the connector is removed from the ECU.

Bendix® WS-24™ Wheel Speed Sensors

Wheel speed data is provided to the Bendix EC-80 controller from the Bendix® WS-24™ wheel speed sensor (see Figure 2). Vehicles have an exciter ring (or “tone ring”) as part of the wheel assembly, and as the wheel turns, the teeth of the exciter ring pass the wheel speed sensor, generating an AC signal. The Bendix EC-80 controller receives the AC signal, which varies in voltage and frequency as the wheel speed changes.

Vehicle axle configurations and ATC features determine the number of Bendix WS-24™ wheel speed sensors that must be used. A vehicle with a single rear axle requires four wheel speed sensors. Vehicles with two rear axles can utilize six wheel speed sensors for optimal ABS and ATC performance.

Diagnostic Blink Code Switch

A momentary switch that grounds the ABS indicator lamp output is used to place the ECU into the diagnostic blink code mode and is typically located on the vehicle’s dash panel.

ABS OFF-ROAD SWITCH AND INDICATOR LAMP OPERATION



The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be affected. When the ECU is placed in the ABS off-road mode, the ABS indicator lamp will flash constantly to notify the vehicle operator that the off-road mode is active.

Bendix EC-80 ATC controllers use a dash-mounted switch to place the ECU into the ABS off-road mode. In some cases, ECUs may also be put into the ABS off-road mode by one of the other vehicle control modules, using a J1939 message to the Bendix EC-80 controller.

If you need to know if a specific ECU uses a J1939 message to operate the lamp, see the Controller Specifications box below.

Stop Lamp Switch (SLS)

Bendix EC-80 ATC ECUs monitor the vehicle stop lamp status. Certain vehicle functions, such as ATC and All-Wheel Drive (AWD), use the status of the stop lamp to know the driver’s intention. This can be provided to the ECU via J1939 communications or hardware input.

BENDIX EC-80 CONTROLLER OUTPUTS

Bendix® M-32™, M-32QR™ and M-40X™ Pressure Modulator Valves (PMV)

The Bendix M-32, M-32QR and M-40X pressure modulator valves (PMV) are operated by the Bendix EC-80 controller to modify driver applied air pressure to the service brakes during ABS or ATC activation (See pages 6-8). The PMV is an electro-pneumatic control valve and is the last valve that air passes through on its way to the brake chamber. The modulator hold and release solenoids are activated to precisely modify the brake pressure during an antilock braking event. The hold solenoid is normally open and the release solenoid is normally closed.

Controller Specifications: *If you need to know exact information about an ECU e.g. if it uses PLC, serial communications, etc., e-mail ABS@Bendix.com, specifying the ECU part number, or call: 1-800-AIR-BRAKE, 1-800-247-2725, option 2, then 1, and speak to the Bendix TechTeam.*

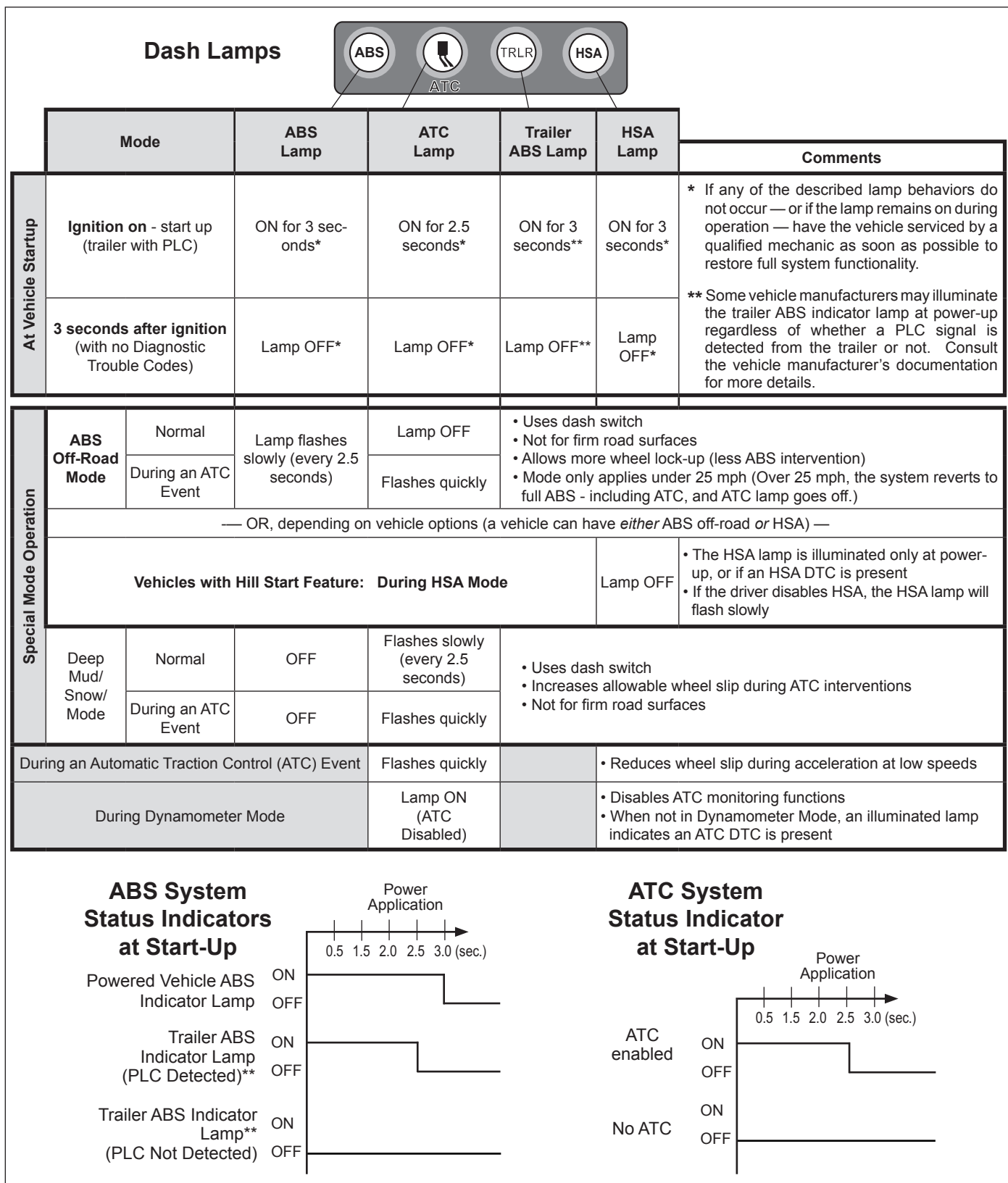


CHART 2 - BENDIX® EC-80™ INDICATOR LAMP BEHAVIOR

Traction Control Valve (TCV)

Bendix EC-80 ATC controllers will activate the TCV during differential braking ATC events. The TCV may be a separate valve or integrated into the rear axle relay valve.

ABS Indicator Lamp Control with Optional Diagnostic Blink Code Switch

Bendix® EC-80™ controllers have internal circuitry to control the ABS indicator lamp on the dash panel.

The ABS Lamp Illuminates:

1. During power-up (e.g. when the vehicle is started) and turns off after the self-test is completed, providing no **Diagnostic Trouble Codes (DTCs)** are present on the tractor.
2. If the ECU is unplugged or has no power.
3. When the ECU is placed into the ABS off-road mode (the lamp flashes rapidly).
4. To display blink codes for diagnostic purposes after the external diagnostic switch is activated.

Certain Bendix® EC-80™ controllers communicate with other vehicle control modules to operate the ABS indicator lamp using. *To confirm if a specific ECU uses serial communications, see the Controller Specifications box on page 4.*

Indicator Lamp Control Using Serial Communications Links

As mentioned above, depending on the vehicle manufacturer, the dash indicator lamps (ABS, ATC and trailer ABS) may be controlled using serial communications link. In these cases, the Bendix EC-80 controller will send a serial communications message over the J1939 links indicating the required status of the lamp(s). Another vehicle control module receives the message and controls the indicator lamp(s).

Retarder Relay Disable Output

The retarder relay disable output may be used to control a retarder disable relay.

When configured to use this output, the ECU will energize the retarder disable relay and inhibit the use of the retarder as needed.

SAE J1939 Serial Communications

A Controller Area Network (CAN) data link (SAE J1939) is provided for communication. This link is used for various functions, such as:

- To disable retarding devices during ABS operation
- To request that the torque converter disable lock-up during ABS operation
- To share information such as wheel speed and ECU status with other vehicle control modules

Bendix EC-80 ATC controllers utilize the J1939 data link for ATC and drag torque control functions.

Trailer ABS Indicator Lamp Control

Certain models of the Bendix EC-80 controller activate a trailer ABS indicator lamp (located on the dash panel) that indicates the status of the trailer ABS unit on one, or more trailers or dollies. Typically, the Bendix EC-80 controller directly controls the trailer ABS indicator lamp based on the information it receives from the trailer ABS.

Alternatively, some vehicles require the Bendix EC-80 controller to activate the trailer ABS indicator lamp by communicating with other vehicle controllers using serial communications. *To confirm if a specific ECU uses serial communications, see the Controller Specifications box on page 4.*

ATC Lamp Output/ATC Off-Road Switch Input

The ATC dash lamp is controlled by the Bendix EC-80 ATC ECU. The ATC lamp illuminates:

1. During power-up (e.g. when the vehicle is started for approximately 2.5 seconds) and turns off after the self-test is completed, providing no Diagnostic Trouble Codes are present.
2. When ATC is disabled for any reason.
3. During an ATC event (the lamp will flash rapidly at a rate of 2.5/second).
4. When the ECU is placed in the ATC off-road mode (the lamp will flash steadily every 2.5 seconds). This notifies the vehicle operator that the off-road mode is active.

Interaxle Differential Lock Control (AWD Transfer Case)

A Bendix EC-80 ATC ECU can control the interaxle differential lock (AWD transfer case). This is recommended on AWD vehicles, but the ECU must be specially configured to provide this feature. *For help with configuring an ECU, use the information in the Controller Specifications box on page 4 to contact Bendix.*

POWER-UP SEQUENCE



The vehicle operator should verify proper operation of all installed indicator lamps (ABS, ATC, and trailer ABS) when applying ignition power and during vehicle operation. See Chart 2 on page 5.

Lamps that do not illuminate as expected when ignition power is applied, or remain illuminated, indicate the need for maintenance.

ABS Indicator Lamp Operation

The ECU will illuminate the ABS indicator lamp for approximately three seconds when ignition power is applied, after which the lamp will extinguish if no Diagnostic Trouble Codes are detected.

The ECU will illuminate the ABS indicator lamp whenever full ABS operation is not available due to a Diagnostic Trouble Code. In most cases, partial ABS is still available.

ATC Status/Indicator Lamp Operation

The ECU will illuminate the ATC lamp for approximately 2.5 seconds when ignition power is applied, after which the lamp will extinguish, if no Diagnostic Trouble Codes are detected.

The ECU will illuminate the ATC indicator lamp whenever ATC is disabled due to a Diagnostic Trouble Code.

Trailer ABS Indicator Lamp Operation

Certain models of the ECU will control the Trailer ABS indicator lamp when a PLC signal (SAE J2497) from a trailer ABS ECU is detected.

Pressure Modulator Valve Chuff Test

Bendix® EC-80™ controllers will perform a Bendix-patented Pressure Modulator Valve (PMV) Chuff Test. The Chuff Test is an electrical and pneumatic PMV test that can assist maintenance personnel in verifying proper PMV wiring and installation.

With brake pressure applied, a properly installed PMV will perform one sharp audible exhaust of air by activating the hold solenoid twice and the release solenoid once. If the PMV is wired incorrectly, it will produce two exhausts of air, or none at all.

The Bendix EC-80 controller will perform a PMV chuff test on all installed modulators in the following order:

- Steer Axle Right PMV
- Steer Axle Left PMV
- Drive Axle Right PMV
- Drive Axle Left PMV
- Additional Axle Right PMV
- Additional Axle Left PMV

The pattern will then repeat itself. See *Figure 6*.

The ECU will not perform the PMV Chuff Test when wheel speed sensors show that the vehicle is in motion.

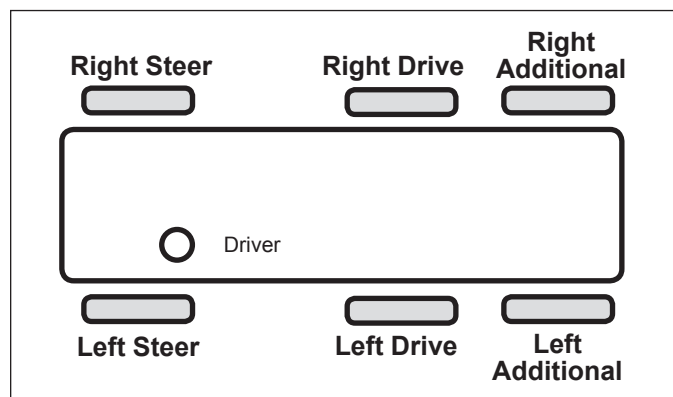


FIGURE 6 - VEHICLE ORIENTATION (TYPICAL)

ABS OPERATION

Bendix® ABS uses wheel speed sensors, ABS modulator valves, and an ECU to control either four or six wheels of a vehicle. By monitoring individual wheel turning motion during braking, and adjusting or pulsing the brake pressure at each wheel, the Bendix EC-80 controller is able to optimize slip between the tire and the road surface. When excessive wheel slip, or wheel lock-up, is detected, the Bendix EC-80 controller will activate the pressure modulator valves to simulate a driver pumping the brakes. However, the Bendix EC-80 controller is able to pump the brakes on individual wheels (or pairs of wheels), independently, and with greater speed and accuracy than a driver.

Steer Axle Control

Although both wheels of the steer axle have their own wheel speed sensor and pressure modulator valve, the Bendix EC-80 controller blends the applied braking force between the two steering axle brakes. This Bendix-patented brake application control, called Modified Individual Control (MIC), is designed to help reduce steering wheel pull during an ABS event on road surfaces with poor traction (or areas of poor traction, e.g., asphalt road surfaces with patches of ice).

Single Drive Axle Control (4x2 Vehicle)

For vehicles with a single rear drive axle (4x2), the brakes are operated independently by the Bendix EC-80 controller, based on the individual wheel behavior.

Dual Drive Axle Control (4S/4M Configuration)

For vehicles with dual drive axles (6x4) using a 4S/4M configuration, one ABS modulator controls both right-side rear wheels, and the other modulator controls both left-side rear wheels. Both wheels on each side receive equal brake pressure during an ABS stop. The rear wheel speed sensors must be installed on the axle with the lightest load.

Dual Rear Axle Control (6S/6M Configuration)

For vehicles with dual rear axles (6x4, 6x2) using a 6S/6M configuration, the rear wheels are controlled independently. Therefore, brake application pressure at each wheel is adjusted according to the individual wheel behavior on the road surface.

6x2 Vehicles with 6S/5M Configuration

6x2 vehicles can utilize a 6S/5M configuration, with the additional axle (a non-driven rear axle) having two sensors, but only one pressure modulator valve. In this case, the PMV controls both wheels on the additional axle. The additional axle wheels would receive equal brake pressure, based on the wheel that is currently experiencing the most wheel slip.

Normal Braking

During normal braking, brake pressure is delivered through the ABS PMV and into the brake chamber. If the ECU does not detect excessive wheel slip, it will not activate ABS control, and the vehicle stops with normal braking.

Retarder Brake System Control

On surfaces with low traction, application of the retarder can lead to high levels of wheel slip at the drive axle wheels, which can adversely affect vehicle stability.

To avoid this, the Bendix EC-80 controller switches off the retarder as soon as a lock-up is detected at one (or more) of the drive axle wheels.

When the ECU is placed in the ABS off-road mode, it will switch off the retarder only when ABS is active on a steer axle wheel and a drive axle wheel.

Optional HSA Mode

As a driver begins to move a vehicle forward when stopped facing up an incline (or backs-up a vehicle when facing down a slope), vehicles without Bendix Hill Start Aid/Assist (HSA) may experience rolling downhill during the delay between the release of the brakes and providing enough torque to move the vehicle up the slope.

For vehicles with Bendix HSA, the ECU receives a J1939 message from the transmission when it will need the assistance of the brakes to avoid the vehicle rolling. The HSA components apply brake pressure to select wheel-end brakes. After three (3) seconds from the driver brake release, the HSA system releases the brake pressure. The three-second delay allows the drive-line components to activate while the vehicle is held in place.



When using the HSA function, the ABS off-road function and the Retarder Relay output are temporarily disabled.

Optional ABS Off-Road Mode

On some road conditions, particularly when the driving surface is soft, the stopping distance with ABS may be longer than without ABS. This can occur when a locked wheel on soft ground plows up the road surface in front of the tire, changing the rolling friction value. Although vehicle stopping distance with a locked wheel may be shorter than corresponding stopping distance with ABS control, vehicle steerability and stability is reduced.

Bendix® EC-80™ ATC controllers have an optional control mode that more effectively accommodates these soft road conditions to shorten stopping distance while maintaining optimal vehicle steerability and stability.



The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be reduced. The flashing ABS indicator lamp communicates the status of this mode to the driver.

The vehicle manufacturer should provide the optional ABS off-road function only for vehicles that operate on unpaved surfaces or that are used in off-road applications. The vehicle OEM is responsible for ensuring that vehicles equipped with the ABS off-road function meet all FMVSS-121 requirements and have adequate operator indicators and instructions.

The vehicle operator activates the off-road function with a switch on the dash panel. A flashing ABS indicator lamp indicates to the driver that the ABS off-road function is engaged. To exit the ABS off-road mode, depress and release the switch.

All-Wheel Drive (AWD) Vehicles

AWD vehicles with an engaged interaxle differential (steer axle to rear axle)/AWD transfer case may have negative effects on ABS performance. Optimum ABS performance is achieved when the lockable differentials are disengaged, allowing individual wheel control.

Bendix EC-80 ATC controllers can be programmed specifically for this configuration to control the differential lock/unlock solenoid in the AWD transfer case. When programmed to do so, the ECU will disengage the locked interaxle/AWD transfer case during an ABS event and reengage it once the ABS event has ended.

ATC OPERATION

ATC Functional Overview

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The Bendix EC-80 ATC controller's ATC function uses the same wheel speed information and modulator control as the ABS function. The ECU detects excessive drive wheel speed; compares the speed of the front, non-driven wheels; and reacts to help bring the wheel spin under control. The ECU can be configured to use engine torque limiting and/or differential braking to control wheel spin. For optimal ATC performance, both methods are recommended.

ATC Lamp Operation

The ATC lamp illuminates:

1. During power-up (e.g. when the vehicle is started for approximately 2.5 seconds) and turns off after the self-test is completed, providing no Diagnostic Trouble Codes are present.
2. When ATC is disabled for any reason.

3. During an ATC event (the lamp will flash rapidly at a rate of 2.5/second). When ATC is no longer active, the ATC active/indicator lamp turns off.
4. When the ECU is placed in the ATC off-road mode (the lamp will flash steadily every 2.5 seconds). This notifies the vehicle operator that the off-road mode is active.

Differential Braking

Differential braking is automatically activated when drive wheel(s) on one side of the vehicle are spinning. This typically occurs on asphalt road surfaces with patches of ice. The traction system will then lightly apply the brake to the drive wheel(s) that are spinning. The vehicle differential will then drive the wheels on the other side of the vehicle.

Differential braking is available at vehicle speeds up to 25 MPH.

Disabling ATC Differential Braking

ATC differential braking is disabled under the following conditions:

1. During power-up (e.g. when the vehicle is started), until the ECU detects a service brake application.
2. If the ECU receives a J1939 message indicating that the vehicle is parked.
3. When the Dynamometer Test Mode is active. The Dynamometer Test Mode is entered using the diagnostic blink code switch or by using a diagnostic tool (such as Bendix® ACom® Diagnostics).
4. In response to a serial communications request from a diagnostic tool.
5. During brake torque limiting to avoid overheating of the brakes.
6. When certain Diagnostic Trouble Code conditions are detected.

Engine Torque Limiting (ETL) with Smart ATC™ Traction Control

The Bendix® EC-80™ controller uses Engine Torque Limiting to control drive axle wheel slip. This is communicated to the engine control module (using J1939), and is available at all vehicle speeds.

Bendix® Smart ATC™ Traction Control

The Bendix EC-80 ATC controller has an additional feature known as Smart ATC™ traction control. Smart ATC™ traction control monitors the accelerator pedal position (using J1939) to help provide optimum traction and vehicle stability. By knowing the driver's intention and adapting the target slip of the drive wheels to the driving situation, the Smart ATC™ traction control allows higher wheel slip when the accelerator pedal is applied above a preset level.

The target wheel slip is decreased when driving through a curve for improved stability.

Disabling ATC Engine Control and Smart ATC™ Traction Control

ATC Engine Control and Smart ATC™ traction control will be disabled under the following conditions:

1. In response to a serial communications request from an off-board tool.
2. At power-up until the ECU detects a service brake application.
3. If the ECU receives a J1939 message indicating that the vehicle is parked.
4. If the Dynamometer Test Mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch.
5. When certain Diagnostic Trouble Code conditions are detected.

Optional ATC Off-Road Mode

In some road conditions, the vehicle operator may desire additional drive wheel slip when ATC is active. The Bendix EC-80 ATC controller has an optional control mode to permit this desired performance.

The vehicle operator can activate the off-road function with a switch on the dash panel. Alternately, a J1939 message may be used to place the vehicle in this mode. The ATC indicator lamp will flash continually to confirm that the off-road ATC function is engaged.

To exit the ATC off-road mode, depress and release the ATC off-road switch.

Drag Torque Control Functional Overview

Bendix EC-80 ATC controllers have a feature referred to as drag torque control which reduces wheel slip on a driven axle due to driveline inertia. This condition is addressed by increasing the engine torque to overcome the inertia.

Drag torque control increases vehicle stability on low-traction road surfaces during down-shifting or retarder braking.

DYNAMOMETER TEST MODE



ATC must be disabled prior to conducting any dynamometer testing. When the Dynamometer Test Mode is enabled, ATC brake control and engine control, along with drag torque control, are turned off. This test mode is used to avoid torque reduction — or torque increase and brake control activation — when the vehicle is operated on a dynamometer for testing purpose.

The Dynamometer Test Mode may be activated by pressing and releasing the diagnostic blink code switch five (5) times or by using a hand-held or PC-based diagnostic tool.

The Dynamometer Test Mode will remain active even if power to the ECU is removed and re-applied. Press and release the blink code switch three (3) times, or use a hand-held or PC-based diagnostic tool to exit the test mode.

AUTOMATIC TIRE SIZE CALIBRATION

The ECU requires a precise rolling circumference ratio between steer axle and drive axle tires in order for ABS and ATC to perform in an optimal manner. For this reason, a learning process continuously takes place in which the precise ratio is calculated. This calculated value is stored in the ECU memory provided the following conditions are met:

1. Rolling-circumference ratio is within the permissible range.
2. Vehicle speed is greater than approximately 15 MPH.
3. No acceleration or deceleration is taking place.
4. There are no active speed sensor Diagnostic Trouble Codes (DTCs).

The ECU is provided with a ratio value of 1.00 as a default setting. If the automatic tire size alignment calculates a different value, this is used to overwrite the original figure in the memory. This process adapts the ABS and ATC function to the vehicle.

Acceptable Tire Sizes

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, and varies with tire size, tire wear, tire pressure, vehicle loading, etc.

The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100-tooth exciter ring, the minimum number of tire revolutions per mile is 426, and the maximum is 567. The ECU will set DTCs if the number of revolutions are out of this range.

ABS PARTIAL SHUTDOWN

Depending which component the trouble code is detected on, the ABS and ATC functions may be fully or partially disabled. Even with the ABS indicator lamp on, the Bendix® EC-80™ controller may still provide ABS function on wheels that are not affected. The ECU should be serviced as soon as possible.

Steer Axle ABS Modulator Diagnostic Trouble Code

ABS on the affected wheel is disabled. ABS and ATC on all other wheels remains active.

Drive Axle/Additional Axle ABS Modulator Diagnostic Trouble Code

ATC is disabled. ABS on the affected wheel is disabled. ABS on all other wheels remains active.

Steer Axle Wheel Speed Sensor Diagnostic Trouble Code

The wheel with the Diagnostic Trouble Code is still controlled by using input from the remaining wheel speed sensor on the front axle. ABS remains active on the rear wheels. ATC is disabled.

Drive Axle/Additional Axle Wheel Speed Sensor Diagnostic Trouble Code

ATC is disabled. In a four sensor system, ABS on the affected wheel is disabled, but ABS on all other wheels remains active.

In a six sensor system, ABS remains active by using input from the remaining rear wheel speed sensor on the same side.

ATC Modulator Diagnostic Trouble Code

ATC is disabled. ABS remains active.

J1939 Communication Diagnostic Trouble Code

ATC is disabled. ABS remains active.

ECU Diagnostic Trouble Code

ABS and ATC are disabled. The system reverts to normal braking.

Voltage Diagnostic Trouble Code

While voltage is out of range, ABS and ATC are disabled. The system reverts to normal braking. When the correct voltage level is restored, full ABS and ATC function is available. Operating voltage range is 9.0 to 17.0 VDC.

Reconfiguring Bendix® EC-80™ Controllers

SYSTEM RECONFIGURATION

The Bendix® EC-80™ controller is designed to allow the technician to change the default system settings (chosen by the vehicle OEM) to provide additional or customized features. When replacing an ECU, be sure to use an equivalent Bendix® replacement part number so that the standard default settings are provided.

Depending on the version, the customizable features include ABS control settings, engine module communication, etc. Many of these settings can be reconfigured using a hand-held diagnostic tool or PC-based software, such as the Bendix® ACom® Diagnostics program.

ECU RECONFIGURATION

Reconfiguring Bendix EC-80 ABS ECUs

Reconfiguring a Bendix EC-80 ABS controller may be carried out by using the Blink Code Switch or by using a hand-held or PC-based diagnostic tool.

Note: During the reconfiguration process, and independently from any reconfiguration being carried out by the technician, standard ECUs automatically check the J1939 serial link and communicate with other vehicle modules. In particular, if the serial link shows that the vehicle has a retarder device present, the ECU will configure itself to communicate with the retarder device for improved ABS performance. For example, if the ECU detects the presence of a retarder disable relay during a reconfiguration, it will configure itself to control the relay to disable the retarding device as needed.

Reconfiguring Bendix EC-80 ATC ECUs

As with non-ATC ECUs, the Bendix EC-80 ATC ECU also carries out — independently from any reconfiguration being carried out by the technician — an automatic check of the J1939 serial link and communicates with other vehicle modules. This includes checking for ATC and retarder disable relay operation. In addition, Bendix EC-80 ATC controllers will determine the number of wheel speed sensors and PMVs installed and configure itself accordingly.

6S/5M Configuration

Bendix EC-80 ATC controllers will configure for 6S/5M operation when a reconfiguration event is initiated and the ECU detects that an additional axle PMV is wired as follows:

PMV Connector	ECU Connector
Hold	Right Additional Axle Hold
Release	Left Additional Axle Release
Common	Right Additional Axle Common

See 6S/5M System Schematic (page 37) for details.

Reconfiguration Using the Blink Code Switch

The reconfiguration procedure is the same for ATC and non-ATC ECUs. With ignition power removed from the Bendix EC-80 controller, depress the blink code switch. After the ignition power is activated, depress and release the switch seven times to initiate a reconfiguration.

Diagnostic Tool

A reconfiguration event may be initiated using a hand-held or PC-based diagnostic tool to communicate with the ECU over the SAE J1939 diagnostic link.

Troubleshooting: General

Read and follow the General Safety Guidelines on page two (2) of this document.

REMOVING THE BENDIX® EC-80™ CONTROLLER ASSEMBLY

1. Turn vehicle ignition off.
2. Remove as much contamination as possible prior to disconnecting air lines and electrical connections.
3. Note the ECU assembly mounting position on the vehicle.
4. Disconnect the electrical connectors from the ECU.
5. Remove and retain the mounting bolts that secure the ECU.

INSTALLING A NEW BENDIX® EC-80™ CONTROLLER



When replacing the Bendix® EC-80™ controller, verify that the unit you are installing has the correct default settings. Failure to do so could result in a loss of features, such as ATC and PLC, or noncompliance with U.S. regulations such as FMVSS 121. It is recommended to use only the correct replacement part number. However, most configuration settings can be altered using the Bendix® ACom® ABS Diagnostic Software program.

Verify correct operation of the Bendix EC-80 controller system and indicator lamps prior to putting the vehicle back into service. Towing vehicles manufactured after March 1, 2001 must support the trailer ABS indicator lamp located on the dash.

For further information, contact either the vehicle manufacturer, Bendix® or your local authorized Bendix® dealer.

1. Position and secure the Bendix EC-80 controller in the original mounting orientation using the mounting bolts retained during removal. When mounting the unit in the cab, use no more torque than is necessary to firmly secure the ECU into position. Over-tightening the mounting hardware can cause damage to the Bendix EC-80 controller.
2. Reconnect the electrical connectors to the ECU.
3. Apply power and monitor the Bendix EC-80 controller power-up sequence to verify proper system operation.

See Troubleshooting: Wiring section beginning on page 32 for more information on wiring harnesses.

Troubleshooting: Blink Codes and Diagnostic Modes

ECU DIAGNOSTICS

The Bendix® EC-80™ controller contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the Bendix EC-80 controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS and ATC functions. (See pages 8-9.)
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle diagnostic connector, typically located on or under the dash (See Figure 7).

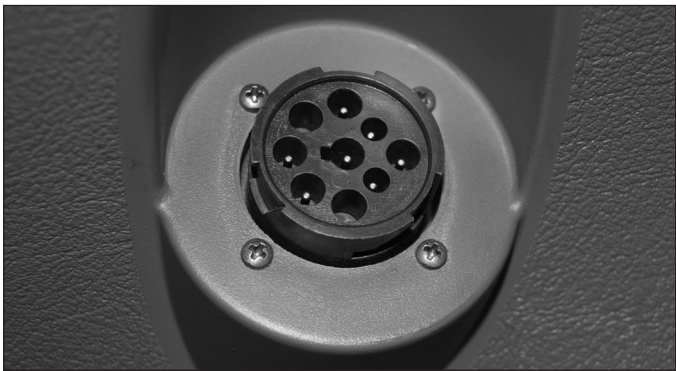


FIGURE 7 - TYPICAL VEHICLE DIAGNOSTIC CONNECTOR LOCATION (J1939)

BLINK CODES

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

Note: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. See Diagnostic Modes below.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after “ignition on.” (Except when entering Reconfiguration Mode - see Reconfiguration section on page 11)
2. For the ECU to recognize that the switch is activated “on,” the technician must press for at least 0.1 seconds, but less than 5 seconds. (If the switch is held for more than 5 seconds, the ECU will register a malfunctioning switch.)
3. Pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than 2 seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks. See Figure 10 for an example.

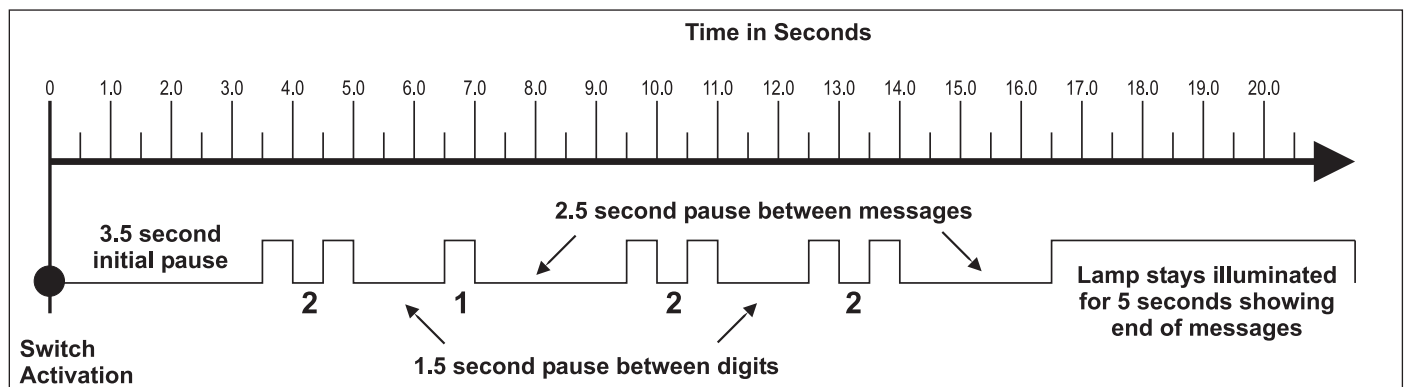


FIGURE 8 - EXAMPLE OF BLINK CODE MESSAGE

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a “message.” Each message includes, depending on the mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the troubleshooting index on page 18 for active or inactive trouble codes. Once you have located the code, you will be directed to the page that provides the applicable troubleshooting information.

NOTE:

1. Blink sequences illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for five (5) seconds at the end of messages.

See Figure 8 for an example showing the message: 2,1 followed by 2,2.

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

DIAGNOSTIC MODES

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Modes

To enter the various diagnostic modes:

No. of Times to Press the Blink Code Switch	System Mode Entered
1	Active Diagnostic Trouble Code (DTC) retrieval
2	Inactive DTC retrieval
3	Clear active DTCs
4	System configuration check
5	Dynamometer Test Mode
7*	Reconfigure ECU
* To enter the Reconfiguration Mode, the switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.	

CHART 3 - DIAGNOSTIC MODES

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the active and inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, etc. (See page 18 for a directory of these codes.) All active trouble codes may also be retrieved using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom® Diagnostics software.

To clear active DTCs (as problems are fixed), simply clear (or “self-heal”) by removing and re-applying ignition power. The only exception is for wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch three (3) times (to enter the Clear Active Diagnostic Trouble Code Mode) or by using a hand-held or PC-based diagnostic tool. Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is commonly referred to as “event history.” When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See page 18 for the index showing trouble codes. Go to the specific troubleshooting guide page shown there for further help.

Inactive trouble codes and event history may be retrieved and cleared by using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom® Diagnostics software.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three (3) times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four (4) times. The lamp will blink out configuration information codes using the following patterns. (See Chart 4).

1st Number	System Power
1	12 Volts
2	24 Volts
2nd Number	Wheel Speed Sensors
4	4 Sensors
6	6 Sensors
3rd Number	Pressure Modulator Valves
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	ABS Configuration
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	Traction Control Configuration
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control & Brake Control)
6th Number	Retarder Configuration
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay

CHART 4 - SYSTEM CONFIGURATION CHECK

In this mode, the ECU tells the technician — by means of a series of six blink codes — the type of ABS system that the ECU has been set up to expect. For example, if the fourth blink code sequence is a three, the technician knows that a 6S/5M sensor/modulator configuration has been set.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable ATC when needed (e.g. when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). This mode is not reset by power off, power on cycling. Instead a hand-held or PC-based diagnostic tool must be used to change the setting. Alternatively, depressing and releasing the blink code switch three times will cause the ECU to exit the blink code mode.

Reconfigure ECU Mode

Vehicle reconfiguration is carried out by using the Reconfigure ECU Mode. (See page 11.) Note: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

Troubleshooting: Using Hand-Held or PC-Based Diagnostic Tools

USING HAND-HELD OR PC-BASED DIAGNOSTICS

Troubleshooting and Diagnostic Trouble Code (DTC) clearing (as well as reconfiguration) may also be carried out using hand-held or PC-based diagnostic tools such as the Bendix® Remote Diagnostic Unit (RDU™), Bendix® ACom® Diagnostics software, or the ProLink™ tool.



FIGURE 9 - THE BENDIX® REMOTE DIAGNOSTIC UNIT (RDU)

Bendix® RDU™ (Remote Diagnostic Unit)

The Bendix® RDU™ tool (Bendix part number K101596N001) provides the technician with a visual indication of Antilock Braking System (ABS) component Diagnostic Trouble Code (DTC) information. The RDU tool is specifically designed for use with Bendix® ABS systems and Bendix makes no claims for its operation and/or usability with other brands of ABS systems.

Features of the Bendix® RDU™ Tool

The RDU tool attaches to the 9 pin diagnostic connector in the cab of the vehicle. An adapter cable (Bendix part number 5012793) is available to connect the RDU to vehicles with a 6-pin diagnostic connector. (See Figure 9.)

The RDU tool allows the technician to:

- Troubleshoot ABS system component problems using DTC reporting via LEDs.
- Reset DTCs on Bendix ABS ECUs by holding a magnet over the reset in the center of the RDU tool for less than 6 seconds.
- Enter the Self-Configuration Mode used by Bendix ABS ECUs by holding a magnet over the reset area for greater than 6 seconds but less than 30 seconds.

How the Bendix RDU Operates

See Figure 7 for typical vehicle connector locations.

When the RDU tool is plugged into the diagnostic connector, all the LEDs will illuminate, and the green LED will flash four (4) times to indicate communications have been established.

If the ABS ECU has no active DTCs, only the green LED will remain illuminated.

If the ABS ECU has at least one active DTC the RDU tool displays the first DTC by illuminating the red LEDs, indicating the malfunctioning ABS component and its location on the vehicle. (See Figure 10.) If there are multiple DTCs on the ABS system, the RDU tool will display one DTC first, then once that DTC has been repaired and cleared, the next code will be displayed.

Typical Combination DTCs are:

- Right steer sensor
- Left steer sensor
- Right drive sensor
- Left drive sensor
- Right additional sensor
- Left additional sensor
- Right steer modulator
- Left steer modulator
- Right drive modulator
- Left drive modulator
- Right additional modulator
- Left additional modulator
- Traction modulator
- ECU
- Engine serial communication

- MOD red LED illuminated, shows the “Common” connection of one or more modulators is shorted to battery or ground
- VLT (Flashing indicates either over- or under-voltage condition)

To pinpoint the root cause and to ensure that the system DTC has been properly corrected, additional troubleshooting may be necessary.

Bendix® RDU™ Reset Function

The magnetic reset switch is located in the center top of the RDU tool. Activation requires a magnet with 30 gauss minimum.

The reset operations are:

1. If the magnet is held over the switch for less than six (6) seconds the “clear Diagnostic Trouble Codes” command is sent.
2. If the magnet is held over the switch for more than six (6) seconds, but less than 30 seconds, the Bendix ABS “self-configuration command” is sent.

Additionally, it is recommended at the end of any inspection that the user switches off and restores the power to the ABS ECU, then check the ABS indicator lamp operation and RDU™ tool to see if they indicate any remaining DTCs.

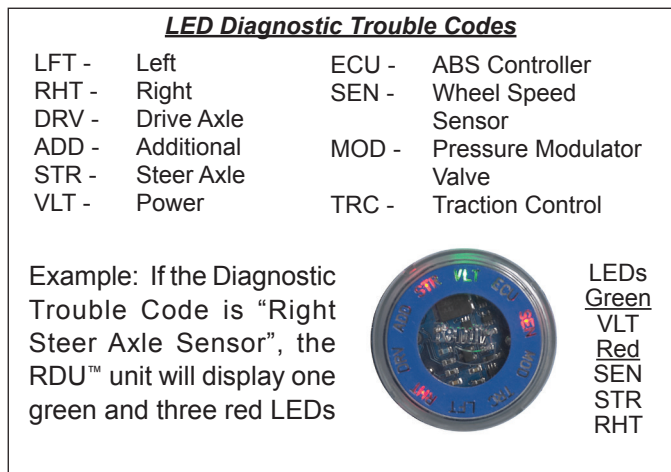


FIGURE 10 - DIAGNOSTIC TROUBLE CODES

Bendix® RDU™ Communication Problems

If the ABS ECU does not respond to the RDU tool's request for Diagnostic Trouble Codes, the RDU tool will illuminate each red LED in a clockwise pattern. This pattern indicates the loss of communication and will continue until the ABS ECU responds and communication has been re-established.

Possible sources of communication problems are:

1. A problem with the J1939 link at the in-cab off-board diagnostic connector (9-Pin).
2. The ECU does not support PID194.
3. No power is being supplied to the ECU and/or the diagnostic connector.
4. The J1939 bus is overloaded with information and the RDU can not arbitrate access.
5. A malfunctioning RDU tool.

Bendix® ACom® Diagnostics Software

Bendix® ACom® Diagnostics is a PC-based software program and is designed to meet RP-1210 industry standards. This software provides the technician with access to all the available ECU diagnostic information and configuration capability, including:

- ECU information
- Diagnostic trouble codes and repair information
- Configuration (ABS, ATC, and more)
- Wheel speed information
- Perform component tests
- Save and print information



FIGURE 11 - BENDIX® ACOM® DIAGNOSTICS

When using ACom® Diagnostics software to diagnose the Bendix® EC-80™ ABS ECU, the computer's serial, parallel or USB port needs to be connected to the vehicle's diagnostic connector.

For more information on ACom Diagnostics software or RP1210 compliant tools, go to www.bendix.com or visit your local authorized Bendix parts outlet.

See pages 40-43 for Appendix: J1939 SPN and FMI codes and their Bendix blink code equivalents.

www.bendix.com

For the latest information, and for free downloads of the Bendix ACom Diagnostics software, and its User Guide, visit the Bendix website at www.bendix.com.

Bendix Technical Assistance Team

For direct telephone technical support, call the Bendix technical assistance team at:

1-800-AIR-BRAKE (1-800-247-2725, option 2,1), Monday through Friday, 8:00 A.M. to 6:00 P.M. ET, and follow the instructions in the recorded message. Or, you may send an e-mail to techteam@bendix.com to reach the Bendix technical assistance team.

Active or Inactive Diagnostic Trouble Code INDEX

How to interpret the first digit of messages received when active or inactive Diagnostic Trouble Code (DTC) Mode is entered.

1st Blink Code Number	Go Here for Troubleshooting Tests
1.....	No DTCs (1,1)
2.....	Wheel Speed Sensors - page 19-20
3.....	Wheel Speed Sensors - page 19-20
4.....	Wheel Speed Sensors - page 19-20
5.....	Wheel Speed Sensors - page 19-20
6.....	Power Supply - page 24
7.....	Pressure Modulator Valves - page 21-22
8.....	Pressure Modulator Valves - page 21-22
9.....	Pressure Modulator Valves - page 21-22
10.....	Pressure Modulator Valves - page 21-22
11.....	J1939 Serial Communications - page 25
12.....	Miscellaneous - page 27-29
13.....	ECU - page 26
14.....	Wheel Speed Sensors - page 19-20
15.....	Wheel Speed Sensors - page 19-20
16.....	Pressure Modulator Valves - page 21-22
17.....	Pressure Modulator Valves - page 21-22
18.....	Traction Control Valves - page 23

Example: For a message sequence of:

3, 2 12, 4

For the first sequence go to page 19 and
for the second sequence go to page 27.

See Page 40 for Appendix: J1939 SPN and FMI Codes and their Bendix® Blink Code Equivalents

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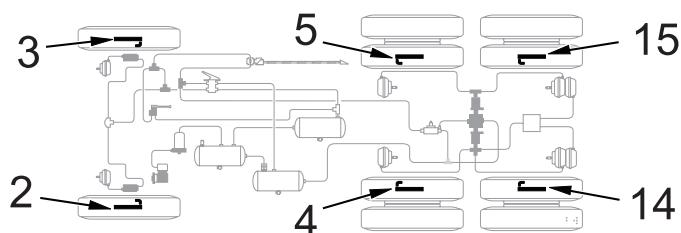
For the latest information, and for free downloads of the Bendix® ACom® Diagnostics software, and its User Guide, visit the Bendix website at www.bendix.com.

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Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors

1st. Blink Code	Location
2	Left Steer Axle Sensor
3	Right Steer Axle Sensor
4	Left Drive Axle Sensor
5	Right Drive Axle Sensor
14	Left Additional Axle Sensor
15	Right Additional Axle Sensor



2nd. Diagnostic Blink Trouble Code Description

Repair Information

1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-off	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500 – 2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
10	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

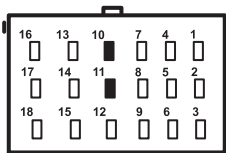
Speed Sensor Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor.
Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

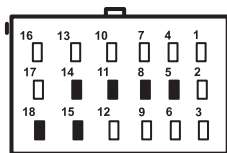
Location	Measurement
Sensor	1500 - 2500 Ohms
Sensor to voltage or ground	Open Circuit (no continuity)
Sensor output voltage	>0.25 of VAC sensor output at ~ 0.5 revs/sec.

3. Clear DTC after issue is corrected. The dynamic sensor DTC will remain until the power is cycled to the ABS ECU and vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

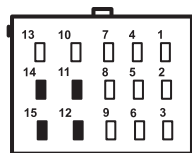
Cab-mount ECU: Looking into wire harness connector



X 1



X 2

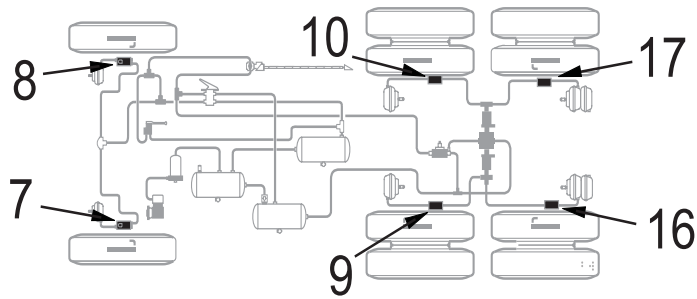


X 3

Connector	Pin	Wheel Speed Sensor Location
X1 18 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
	15	Left Drive Axle (+)
	18	Left Drive Axle (-)
X3 15 Way (if Bendix® EC-80™ ATC ECU is configured for 6 sensors)	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

Troubleshooting Diagnostic Trouble Codes: Pressure Modulator Valves

1st. Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle



2nd. Diagnostic Blink Trouble Code Description

Repair Information

1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.

Pressure Modulator Valve Repair Tests:

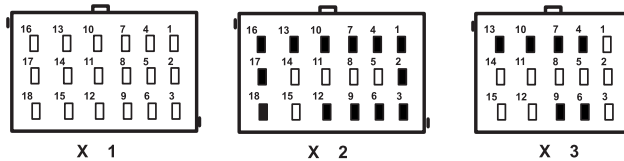
1. Take all measurements at ECU harness connector pins in order to check wire harness and PMV. Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)



When troubleshooting modulator trouble codes, check inactive trouble codes and event history for over-voltage or trouble codes. If one of these is found, troubleshoot these trouble codes first, before the PMV.

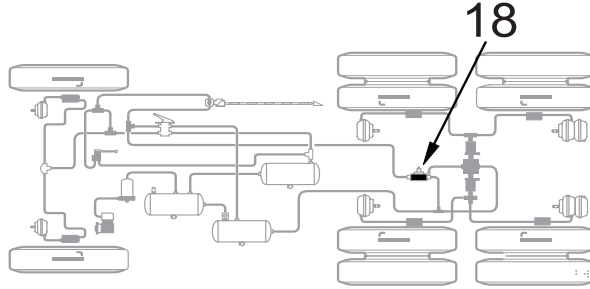
Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X2 18 Way	1	Left Steer Axle Hold
	2	Left Steer Axle Release
	3	Left Steer Axle Common
	4	Right Steer Axle Hold
	6	Right Steer Axle Common
	7	Right Steer Axle Release
	9	Right Drive Axle Common
	10	Right Drive Axle Hold
	13	Right Drive Axle Release
	12	Left Drive Axle Common
	16	Left Drive Axle Hold
X3 15 Way (if Bendix® EC-80™ ATC ECU is configured for 6 sensors)	17	Left Drive Axle Release
	4	Left Additional Axle Hold
	6	Left Additional Axle Common
	7	Left Additional Axle Release
	9	Right Additional Axle Common
	10	Right Additional Axle Hold
	13	Right Additional Axle Release

Troubleshooting Diagnostic Trouble Codes: Traction Control Valves

1st. Blink Code
18 **Location**
Traction Control Valve



2nd. Diagnostic Blink Code
18 **Diagnostic Trouble Code Description**

Repair Information

- | | | |
|---|---------------------------------|--|
| 1 | TCV Solenoid Shorted to Ground | Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded/damaged wiring or connectors between ECU and TCV. |
| 2 | TCV Solenoid Shorted to Voltage | Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and voltage. Check for corroded/damaged wiring or connectors between ECU and TCV. |
| 3 | TCV Solenoid Open Circuit | Verify 7 to 19 ohms between TCV and TCV common. Check for corroded/damaged wiring or connectors between ECU and TCV. |
| 4 | TCV Configuration Error | The ECU is not configured for ATC, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration. |

Automatic Traction Control Valve Inspections should include:

- Looking for kinked air hoses, inside the harness socket for removed or corroded connector pins; and a test to verify that the ATC valve solenoids are functioning correctly.

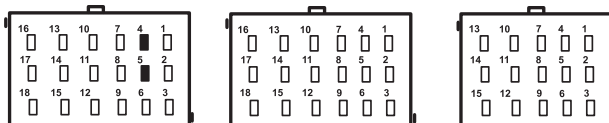
Repair Tests:

- Take all measurements at ECU harness connector pins in order to check wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.
- Tractor Control Valve resistance measurements should read:

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
TCV or TCV Common to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU:

Looking into wire harness connector



Connector	Pin	Traction Control Test
X1	4	Traction Control Valve Common
18 Way	5	Traction Control Valve

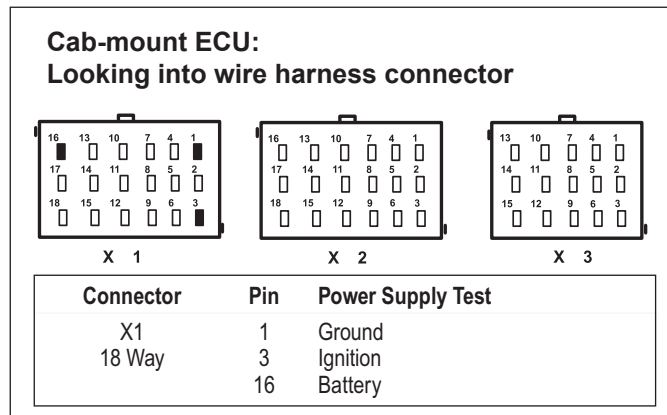
Troubleshooting Diagnostic Trouble Codes: Power Supply

1st. Blink Code	Location
6	Power Supply

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Battery Voltage Too Low	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High	Measure battery voltage under load. Ensure that battery voltage is correct for the ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.

Power Supply Tests:

1. Take all measurements at ECU harness connector.
2. Place a load (e.g. an 1157 stop lamp) across battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition-to-Ground should measure between 9 to 17 VDC. Battery-to-Ground should also measure between 9 to 17 VDC.
3. Check for damaged wiring, damaged or corroded connectors and connections.
4. Check condition of vehicle battery and associated components, ground connection good and tight.
5. Check alternator output for excessive noise.



Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

1st. Blink Code	Location
11	J1939

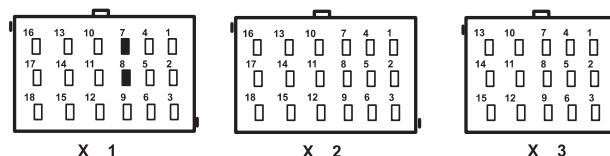
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial Link Loss of Communications	Loss of communications between the Bendix® EC-80™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Electronic Retarder Timeout or Invalid Signal (ERC1)	Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Verify that the retarder is configured to broadcast ERC1. Check for other devices inhibiting J1939 communications.
3	J1939 Electronic Engine Controller 1, Timeout or Invalid Signal (EEC1)	Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of ECU on the J1939 link. Verify ECU Configuration. Verify the ECU is configured to broadcast EEC1. Check for other devices inhibiting J1939 communications.
4	J1939 Electronic Engine Controller 2 Timeout or Invalid Message (EEC2)	Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of Engine ECU on the J1939 link. Verify ECU Configuration. Verify that there is an EEC2 broadcast from the address configured in the ABS ECU. Check for other devices inhibiting J1939 communications.
10	J1939 Transmission Loss of Communications, ETC1 Message	Loss of communications between the Bendix EC-80 controller and the transmission ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
15	J1939 Engine Loss of Communications, EEC3 Message	Loss of communications between the Bendix EC-80 controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
16	J1939 Engine Loss of Communications, ETC2 Message	Loss of communications between the Bendix EC-80 controller and the transmission ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.

J1939 Troubleshooting Tests:

1. Take all measurements at ECU harness connector.
2. Check for damaged or reversed J1939 wiring.
3. Check for corroded or damaged wiring connector problems such as opens or shorts to voltage or ground.
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication.

Cab-mount ECU:

Looking into wire harness connector



Connector	Pin	J1939
X1	7	J1939 Low
18 Way	8	J1939 High

Troubleshooting Diagnostic Trouble Codes: ECU

1st. Blink Code	Location
13	ECU

2nd Blink Code	Diagnostic Trouble Code Description (With HEX designation)	Repair Information
1	ECU DTC (5F3)	Check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If Diagnostic Trouble Codes return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725, option 2, then 1) for further troubleshooting assistance.
2	ECU DTC (5CD)	
3	ECU DTC (10)	
4	ECU DTC (2678C)	
5	ECU DTC (1C)	
6	ECU DTC (6CD)	
7	Configuration mismatch	Verify components installed match ECU configuration
8	ECU DTC (56)	Check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If Diagnostic Trouble Codes return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725, option 2, then 1) for further troubleshooting assistance.
9	ECU DTC (CAC3)	
10	ECU DTC (5FC)	
11	ECU DTC (F1A)	
12	ECU DTC (F14)	
13	Configuration mismatch	Verify components installed match ECU configuration
14	ECU DTC (C6)	Check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If Diagnostic Trouble Codes return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725, option 2, then 1) for further troubleshooting assistance.
15	ECU DTC (CF)	
16	ECU DTC (C0)	
17	ECU DTC (C8C)	
18	ECU DTC (CC)	
19	ECU DTC (63)	
20	ECU DTC (6E)	
21	ECU DTC (6C)	
22	ECU DTC (63C)	
26	Valve Configuration Mismatch	Verify number of modulators wired matches components installed match ECU configuration

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st. Blink Code	Location	
12	Miscellaneous	
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the Bendix® EC-80™ controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	ATC Disabled or Dynamometer Test Mode Active	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. ATC is disabled.
4	Retarder Relay Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay. Verify ECU configuration. Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of Bendix EC-80 controller and ground. Verify condition and wiring of the retarder relay.
5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of Bendix EC-80 controller and voltage. Verify condition and wiring of the retarder relay.
6	ABS Indicator Lamp Circuit Fault	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch, and ABS WL. Verify ABS WL ground input.
7	Common Shorted to Ground	Verify no continuity between the CMN of all PMVs, (HSA, TCV, and Diff Lock Solenoid — Bendix EC-80 ATC options) and ground. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, (HSA, TCV, and Diff Lock Solenoid — Bendix EC-80 ATC options).
8	Common Shorted to Voltage	Verify no continuity between the CMN of all PMVs, (HSA, TCV, and Diff Lock Solenoid — Bendix EC-80 ATC options) and voltage. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, (HSA, TCV, and Diff Lock Solenoid — Bendix EC-80 ATC options).
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection, and wiring of the sensors.
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st. Blink Code	Location	
12	Miscellaneous	

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
17	ABS disabled due to off-road mode	The ABS indicator lamp will be flashing, indicating the ECU is in the off-road ABS mode. Remove and re-apply ignition power.
19	Maximum number of PMV cycles exceeded	Replace all PMV valves and clear the DTC.
20	Maximum Number of TCV Cycles Exceeded	Replace all TCV valves and clear the DTC.
21	ABS Disabled Due to Engaged Interlock	The ABS indicator lamp will be flashing to indicate that the ECU is in the ABS Off-road Mode. Remove and re-apply ignition power.
23	I/O 3 Shorted High	Check for short circuit condition between voltage and the I/O 3 circuit. Verify the resistance between the Input/Output and voltage is open.
24	HSA Lamp Open Circuit or Shorted to GND	Verify that the resistance measured between the battery and HSA lamp output of the ECU is open. Check the wiring between the ECU and the HSA lamp. Check the condition and wiring of the HSA lamp.
25	HSA Valve Solenoid is Shorted to GND	Verify that there is no resistance measured between ground and the HSA solenoid. Check for corroded or damaged wiring or connectors between the ECU and the HSA solenoid.
26	HSA Valve Solenoid is Shorted to Voltage	Verify that there is no resistance measured between voltage and the HSA solenoid. Check for corroded or damaged wiring or connectors between the ECU and the HSA solenoid.
28	Air system/ Mechanical Component	Verify brakes are operating correctly. Verify that there is not over-braking at one or more wheel end(s). Check the pneumatic plumbing and the exhaust port of the PCVs, TCVs, and relay valves and confirm that the air is being exhausted from all brake chambers. Verify tire sizes on the vehicle match the ABS ECU configuration. Verify wheel speed sensors and tone ring are properly adjusted and in good condition.
29	Air system/ Mechanical Component	Verify tires are in good condition. Verify pneumatic hoses are not twisted or kinked. Verify that the brakes are operating correctly. Verify that the wheel speed sensor and tone ring are properly adjusted. Verify tire size.
31	HSA Lamp Shorted to Voltage	Verify that there is no resistance measured between the battery and HSA lamp output of the ECU. Check the wiring between the ECU and HSA lamp. Check the HSA lamp and condition of its wiring.
33	HSA Lamp Solenoid Open Circuit	Verify resistance across the HSA solenoid. Check the ECU and HSA solenoid for corroded or damaged wiring and/or connectors.

Miscellaneous Troubleshooting

For all tests below, take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.

Stop Lamp Switch Test

1. With the service brake applied, measure the system voltage (9 to 17 VDC) stop lamp switch input to ECU.

Test	Measurement
Stop Lamp Switch to Ground	9 to 17 VDC

2. Apply and release service brake, does lamp extinguish?
3. Verify brake lamp switch is connected to ECU via hard wire or J1939.
4. With service brake released, check for presence of stop lamp bulb.

Dynamometer Test Mode (ATC Indicator Lamp Continuously Illuminated)

1. Clear the Dynamometer Test Mode by depressing and releasing the blink code switch three times (or use an off-board diagnostic tool).

ABS Indicator Lamp

1. Verify diagnostic blink code switch is open when not activated.

Retarder Relay

1. Measure resistance between retarder disable output of Bendix® EC-80™ controller and voltage / ground.

Test	Measurement
Retarder disable to Voltage or Ground	Open Circuit (no continuity)

2. Verify vehicle has retarder relay.
3. Verify proper wiring from ECU to retarder relay.

PMV Commons

1. Measure resistance between any common (PMV, TCV, and Diff.) and voltage or ground.

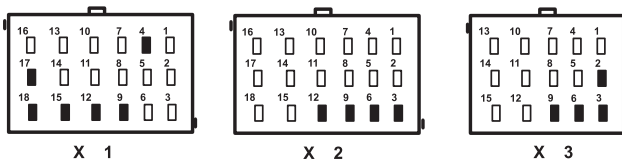
Test	Measurement
Any PMV, TCV, or Diff. Common to Voltage or Ground	Open Circuit (no continuity)

Differential Lock Solenoid

1. Measure resistance between Diff lock solenoid and voltage or ground.

Test	Measurement
Diff. Lock Solenoid to Voltage or Ground	Open Circuit (no continuity)

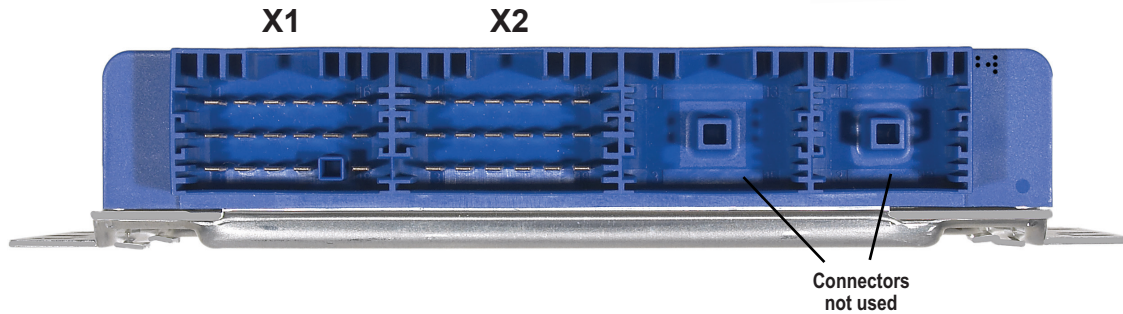
Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X1 18 Way	4	TCV Common
	9	Stop Lamp Switch
	12	ABS WL Ground
	15	ABS WL Interlock
	17	Retarder
X2 18 Way	18	ABS WL
	3	PMV Left Steer Axle Common
	6	PMV Right Steer Axle Common
	9	PMV Right Drive Axle Common
X3 15 Way	12	PMV Left Drive Axle Common
	2	Diff Lock Solenoid
	3	Diff Lock Solenoid Common
	6	PMV Left Additional Axle Common
	9	PMV Right Additional Axle Common

Troubleshooting: Connectors and Harnesses

Bendix® EC-80™ ABS Controller Wire Harness Connector Part Numbers and Pin Assignments: Bendix EC-80 ABS CAB



Bendix EC-80 ABS Controller

Bendix EC-80 ABS versions utilize two AMP connectors for wire harness connections.

Connector Designation	Number of Contacts	AMP Part Number
X1	17	1718091-1
X2	18	8-968974-1

Bendix EC-80 ABS X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	Not Used
2	Trailer ABS WL	8	J1939 High	14	Not Used
3	Ignition	9	Not Used	15	ABS WL Interlock
4	Not Used	10	WSS DA Right (+)	16	Battery
5	Not Used	11	WSS DA Right (-)	17	Retarder
6	Not Used	12	ABS WL Ground	18	ABS WL

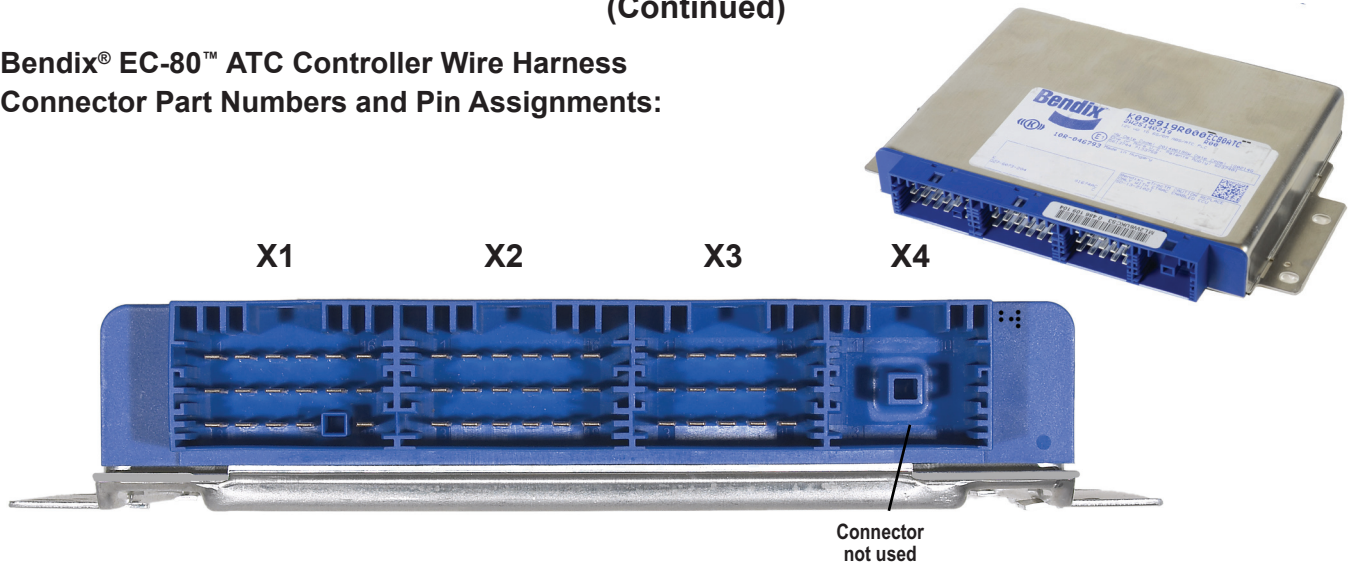
Bendix EC-80 ABS X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

Troubleshooting: Connectors and Harnesses

(Continued)

Bendix® EC-80™ ATC Controller Wire Harness Connector Part Numbers and Pin Assignments:



Bendix EC-80 ATC Controller

Bendix EC-80 ATC versions utilize three AMP connectors for wire harness connections.

Connector Designation	Number of Contacts	AMP Part Number
X1	17	1718091-1
X2	18	8-968974-1
X3	15	8-968973-1

Bendix EC-80 ATC X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	Not Used
2	Trailer ABS WL	8	J1939 High	14	Not Used
3	Ignition	9	SLS	15	ABS WL Interlock
4	TCV CMN	10	WSS DA Right (+)	16	Battery
5	TCV	11	WSS DA Right (-)	17	Retarder
6	ATC Lamp/ATC ORS	12	ABS WL Ground	18	ABS WL

Bendix EC-80 ATC X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

Bendix EC-80 ATC X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	ABS ORS	6	PMV AA Left CMN	11	WSS AA Left (+)
2	Diff. Lock SOL ¹	7	PMV AA Left REL	12	WSS AA Right (+)
3	Diff. Lock SOL CMN ¹	8	Input/Output 3	13	PMV AA Right REL
4	PMV AA Left HLD	9	PMV AA Right CMN	14	WSS AA Left (-)
5	Input/Output 2	10	PMV AA Right HLD	15	WSS AA Right (-)

¹AWD vehicles only. (AWD Transfer Case)

Troubleshooting: Wiring

ABS/ATC WIRING

ECU Wiring Harness Connectors

Bendix® EC-80™ controllers are designed to interface with AMP MCP 2.8 connectors as referenced in Chart 4. Follow all AMP requirements for the repair of wire harnesses.

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.



All unused ECU connectors must be covered and receive proper environmental protection.

ABS Wiring Requirements

As a matter of good practice and to ensure maximum system robustness, always use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.



All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.



Wire harness lengths must be carefully selected for the vehicle. Harnesses that are too long increase the possibility of electrical interference and wire damage. Excess lengths of wire are not to be wound to form coils, instead re-route, repair or replace wire harness. Do not attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

ABS Component	Connector	Wire Terminal	Wire Seal/ Plug	Terminal Lock	Terminal Crimp Tool
Controller Harness 17-Way AMP MCP 2.8 (X1)	 1718091-1	 927768-9 1 - 2.5 mm ² X1-12 & 18	N/A	 967634	 539723-2
Controller Harness 18-Way AMP MCP 2.8 (X2)	 8-968974-1	 968874 2.5 - 4 mm ²	N/A	N/A	
Controller Harness 15-Way AMP MCP 2.8 (X3)	 8-968973-1	 968873 1.0 - 2.5 mm ²	N/A	N/A	
ABS Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-2	 929975-1	N/A	N/A	 539635-1
ATC Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-3		N/A	N/A	
ABS Modulator Harness 3-pin Packard Metri-Pack 280 Series	 12040977	 12077411	 12015323	 12034145	 12155975
WS-24™ Wheel Speed Sensor Connectors <div>  Deutsch DTM06 series  Deutsch DT04 series  Standard round two pin </div>					

CHART 5 - BENDIX® EC-80™ CONTROLLER COMPONENT CONNECTORS

Troubleshooting: Wiring

(CONTINUED)

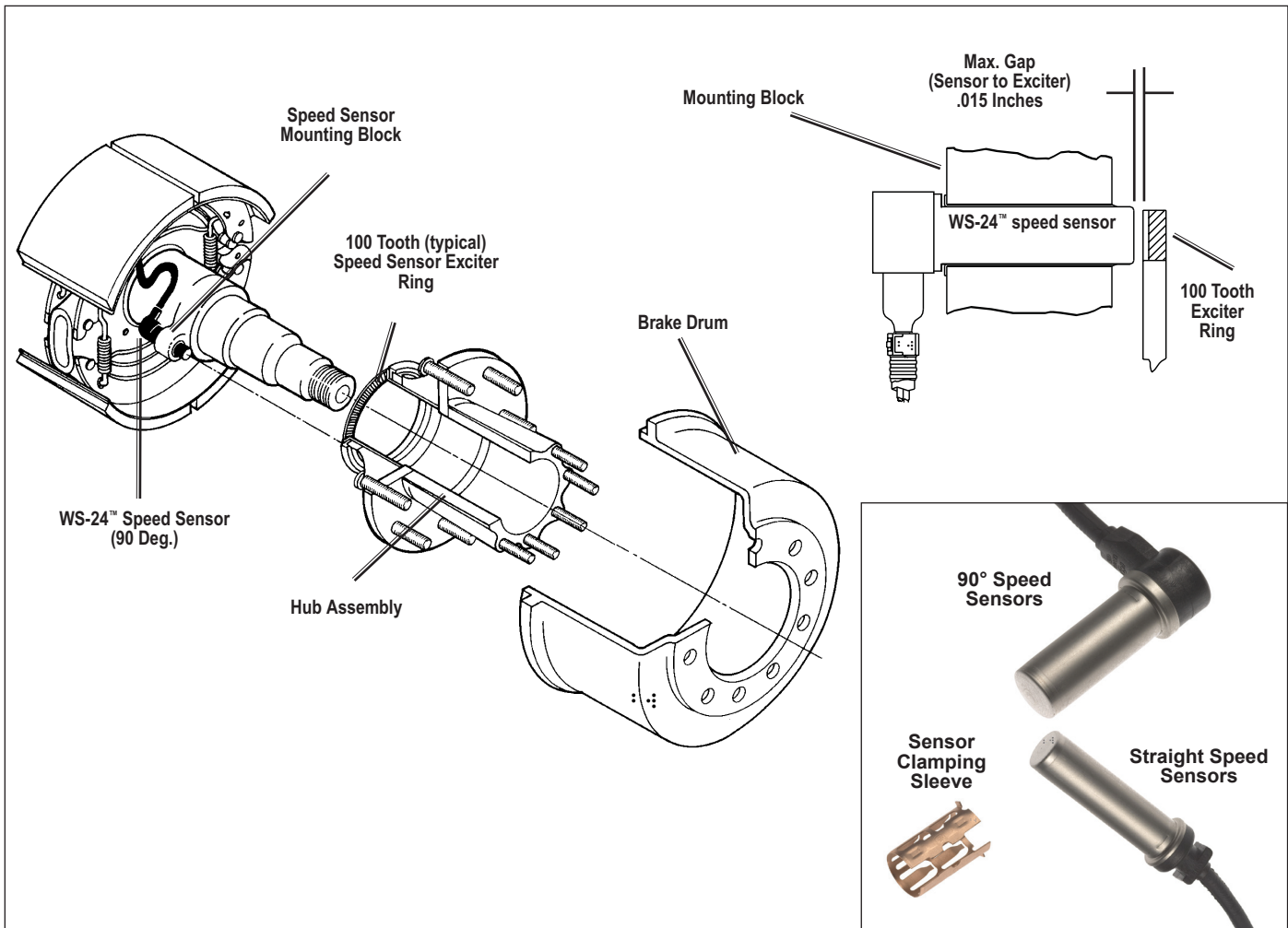


FIGURE 12 - **BENDIX® WS-24™ WHEEL SPEED SENSOR INSTALLATION**

Wheel Speed Sensor Wiring

Route sensor wiring coming out of the wheel ends away from moving brake components. Sensor wiring needs to be secured to the axle to prevent excess cable length and wiring damage. It is required that cable ties be installed to the sensor wire within 3 inches (76.2 mm) of the sensor head to provide strain relief.

Following the axle, the sensor wires must be attached along the length of the service brake hoses using cable ties with ultraviolet protection and secured every 6 to 8 inches (152 to 203 mm). Sufficient – but not excessive – cable length must be provided to permit full suspension travel and steering axle movement. Install wires so that they cannot touch rotating elements such as wheels, brake discs or drive shafts. Radiation protection may be necessary in the area of brake discs.

Bendix does not recommend using standard tie-wraps to secure wiring harnesses directly to rubber air lines. This may cause premature wiring failure from the pressure exerted on the wiring when air pressure is applied through the air line. Non-metallic hose clamps or bow-tie tie-wraps are preferred.

The use of grommets or other suitable protection is required whenever the cable must pass through metallic frame members.

All sensor wiring must utilize twisted pair wire, with approximately one to two twists per inch.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Troubleshooting: Bendix® EC-80™ ABS Wiring Schematic (4S/4M)

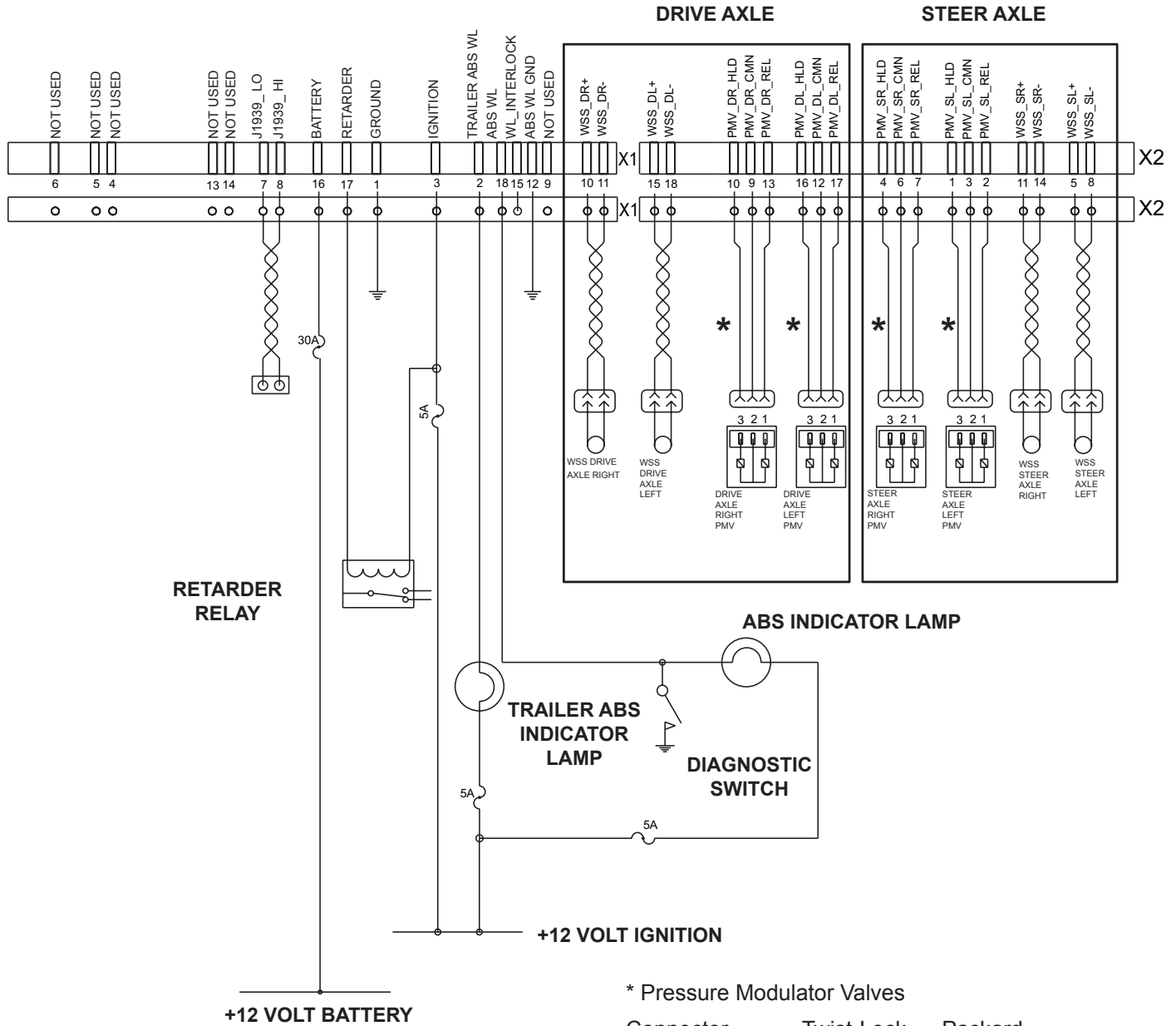


FIGURE 16 - BENDIX® EC-80™ ABS WIRING SCHEMATIC (4S/4M)

Troubleshooting: Bendix® EC-80™ ATC Wiring Schematic (6S/6M)

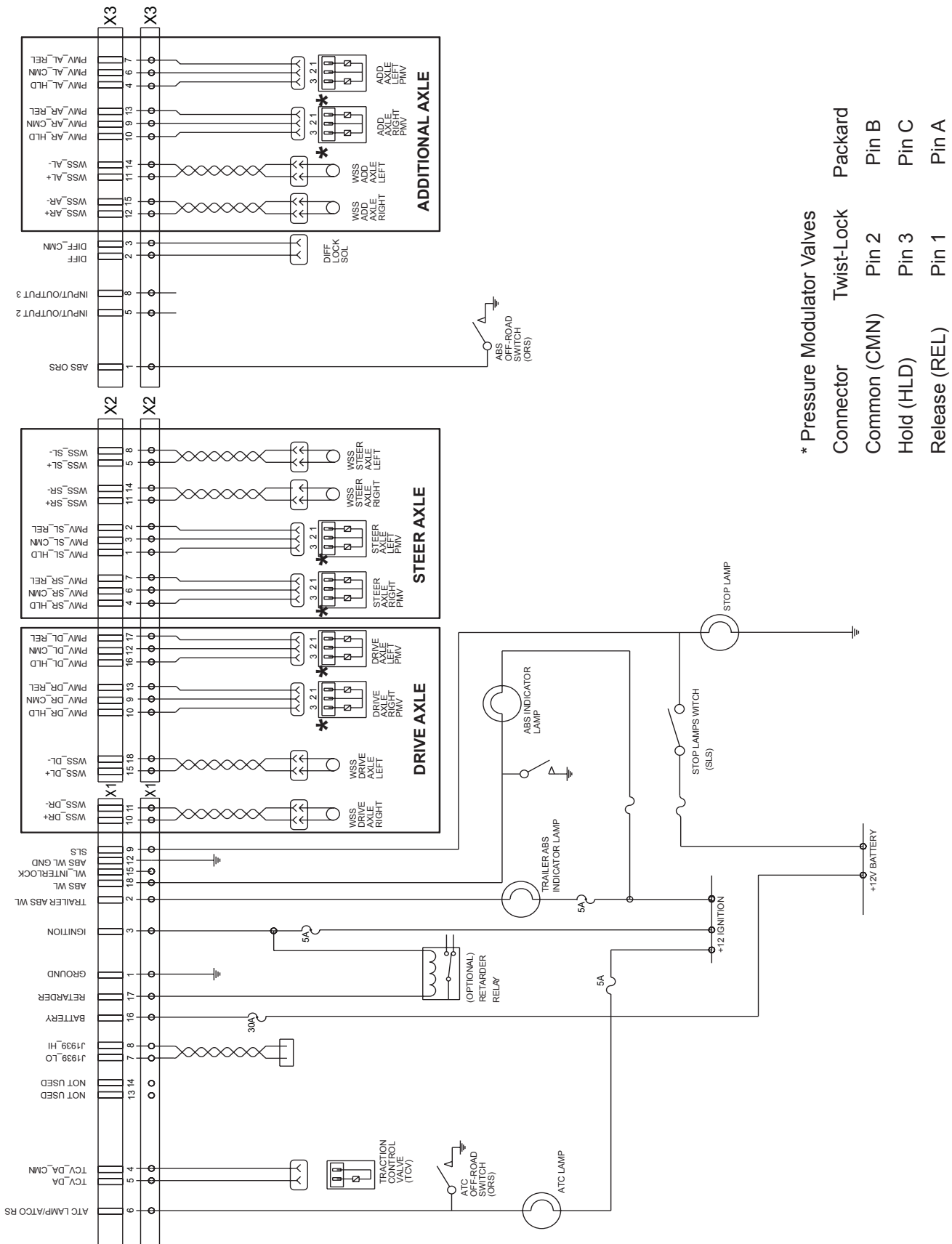


FIGURE 17 - BENDIX® EC-80™ ABS WIRING SCHEMATIC (6S/6M)

Troubleshooting: Bendix® EC-80™ ATC Wiring Schematic (6S/5M)

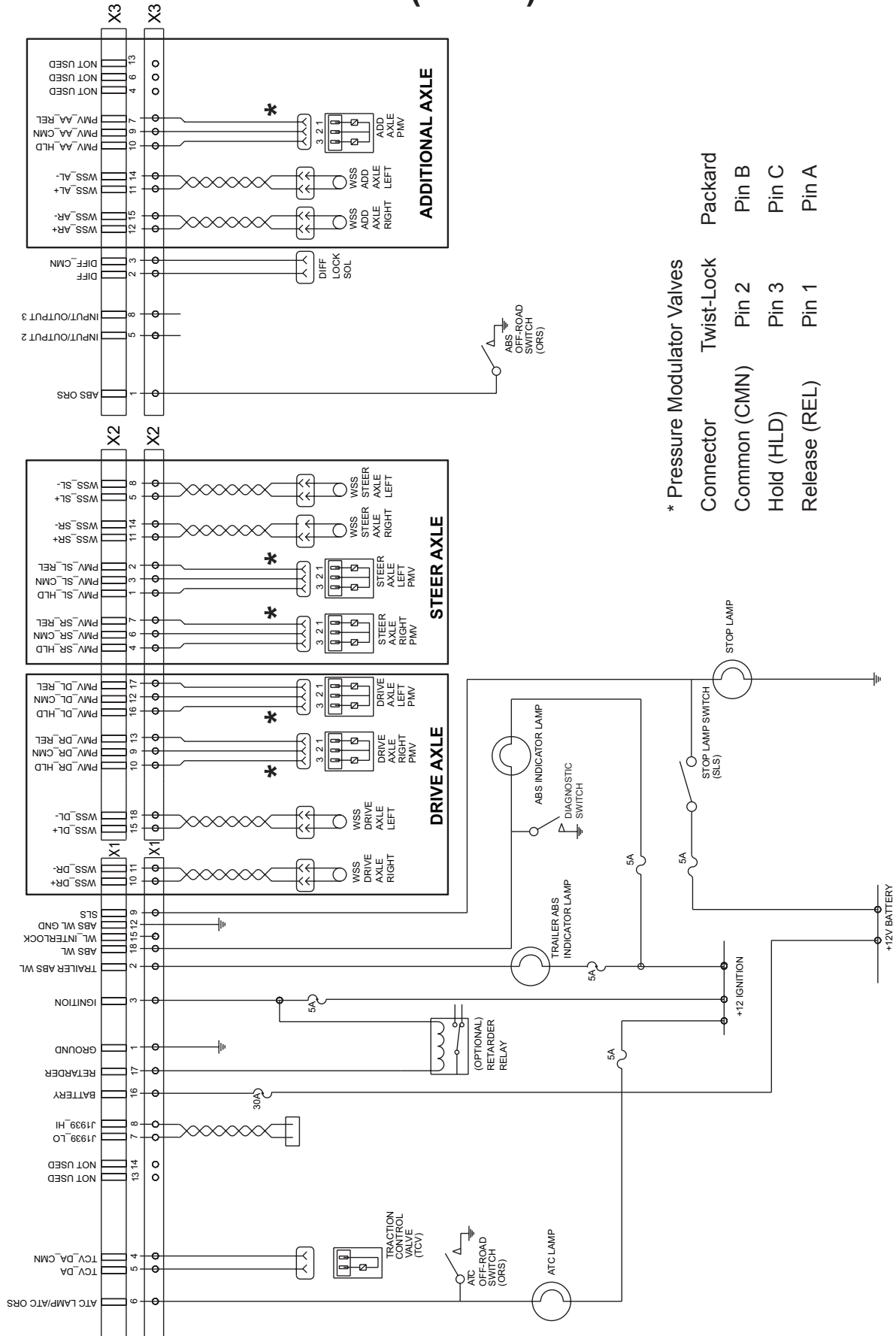


FIGURE 18 - BENDIX® EC-80™ ATC WIRING SCHEMATIC (6S/5M)

NOTES

GLOSSARY

ABS — Antilock Brake System.

ABS Event — Impending wheel lock situation that causes the ABS controller to activate the modulator valve(s).

ABS Indicator Lamp — An amber lamp which indicates the operating status of an antilock system. When the indicator lamp is on, ABS is disabled and the vehicle reverts to normal brake operation.

Air Gap — Distance between the Sensor and tone ring.

ASR — Automatic Slip Regulation. Another name for traction control.

ATC — Automatic Traction Control. An additional ABS function in which engine torque is controlled and brakes are applied differentially to enhance vehicle traction.

ATC/ESP Lamp — A lamp that indicates when stability functions, including traction control, roll stability program or yaw control are operating.

Channel — A controlled wheel site.

CAN — Controller Area Network. J1939 is an SAE version of the CAN link.

Clear Codes — System to erase historical diagnostic trouble codes from the ECU, from either the Diagnostic Switch or from a hand-held diagnostic tool (only repaired diagnostic trouble codes may be cleared).

Configuration — The primary objective is to identify a “normal” set of sensors and modulators for the Electronic Control Unit, so that it will identify future missing sensors and modulators.

Diagnostic Connector — Diagnostic receptacle in vehicle cab for connection of J1587 hand-held or PC-based test equipment. The tester can initiate test sequences, and can also read system parameters.

Diagnostic Switch — A switch used to activate blinks codes.

Differential Braking — Application of brake force to a spinning wheel so that torque can be applied to wheels which are not slipping.

ECU — Electronic Control Unit.

ESP — Electronic Stability Program. Full stability function that includes RSP & YC subfunctions.

Diagnostic Trouble Code — A condition that interferes with the generation or transmission of response or control signals in the vehicle's ABS system that could lead to the functionality of the ABS system becoming inoperable in whole or in part.

FMVSS-121 — Federal Motor Vehicle Safety Standard which regulates air brake systems.

HSA — Hill Start Assist. HSA interfaces between the transmission and braking system to help the driver prevent the vehicle from rolling downhill when moving up a steep incline from a stationary position.

IR — Independent Regulation. A control method in which a wheel is controlled at optimum slip, a point where retardation and stability are maximized. The brake pressure that is best for the wheel in question is directed individually into each brake chamber.

J1587 — The SAE heavy-duty standard diagnostic data link.

J1708 — An SAE standard which defines the hardware and software protocol for implementing 9600 baud heavy vehicle data links. J1587 version of a J1708 data link.

J1939 — A high speed 250,000 baud data link used for communications between the ABS ECU engine, transmission and retarders.

LAS — Lateral Acceleration Sensor.

MIR — Modified Independent Regulation. A method of controlling the opposite sides of a steer axle during ABS operation so that torque steer and stopping distance are minimized.

PLC — Power Line Carrier. The serial communication protocol used to communicate with the trailer over the blue full time power wire.

PMV — Pressure Modulator Valve. An air valve which is used to vent or block air to the brake chambers to limit or reduce brake torque.

QR — Quick Release. Quick release valves allow faster release of air from the brake chamber after a brake application. To balance the system, quick release valves have hold off springs that produce higher crack pressures (when the valves open).

Relay Valve — Increases the application speed of the service brake. Installed near brakes with larger air chambers (type 24 or 30). The treadle valve activates the relay valve with an air signal. The relay valve then connects its supply port to its delivery ports. Equal length air hose must connect the delivery ports of the relay valve to the brake chambers.

Retarder Relay — A relay which is used to disable a retarder when ABS is triggered.

RSP — Roll Stability Program. An all-axle ABS solution that helps reduce vehicle speed by applying all vehicle brakes as needed, reducing the tendency to roll over.

SAS — Steering Angle Sensor.

Sensor Clamping Sleeve — A beryllium copper sleeve which has fingers cut into it. It is pressed between an ABS sensor and mounting hole to hold the sensor in place.

Stored Diagnostic Trouble Codes — A diagnostic trouble code that occurred.

TCS — Traction Control System, another name for ATC or ASR.

Tone Ring — A ring that is usually pressed into a wheel hub that has a series of teeth (usually 100) and provides actuation for the speed sensor. Note maximum run out is .008.

YC — Yaw Control. Helps stabilize rotational dynamics of vehicle.

YRS — Yaw Rate Sensor.

Appendix: J1939 SPN and FMI Codes and their Bendix Blink Code Equivalents

APPENDIX: J1939 SPN and FMI Codes and their Bendix Blink Code Equivalents					
SPN (J1939)	FMI (J1939)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
154	13	Miscellaneous	12	23	I/O 2 or I/O 3 Shorted High
168	3	Power Supply	6	2	Battery Voltage Too High
168	4	Power Supply	6	1	Battery Voltage Too Low
564	3	Miscellaneous	12	13	Diff Lock Solenoid Shorted to Voltage
564	4	Miscellaneous	12	12	Diff Lock Solenoid Shorted to Ground or Open Circuit
575	14	Miscellaneous	12	17	ABS Disabled Due to Off-Road Mode
576	14	Miscellaneous	12	3	ATC Disabled or Dynamometer Test Mode Active
612	14	Miscellaneous	12	21	ABS Disabled Due to Engaged Differential Lock
614	3	Miscellaneous	12	23	IO3 Solenoid Shorted to Voltage
615	14	Miscellaneous	12	19	Maximum Number of PMV Cycles Exceeded
615	14	Miscellaneous	12	20	Maximum Number of TCV Cycles Exceeded
629	2	ECU	13	4	ECU (2678C)
629	2	ECU	13	5	ECU (1C)
629	2	ECU	13	7	Configuration Mismatch
629	2	ECU	13	17	ECU (C8C)
629	8	Miscellaneous	12	29	Air System/Mechanical Component
629	12	ECU	13	3	ECU (10)
629	12	ECU	13	14	ECU (C6)
629	12	ECU	13	15	ECU (CF)
629	12	ECU	13	16	ECU (C0)
629	14	Miscellaneous	12	28	Air System/Mechanical Component
629	14	ECU	13	1	ECU (5F3)
630	12	ECU	13	6	ECU (6CD)
630	12	ECU	13	19	ECU (63)
630	12	ECU	13	20	ECU (6E)
630	12	ECU	13	10	ECU (5FC)
630	13	ECU	13	13	Configuration Mismatch
630	13	ECU	13	2	ECU (5CD)
630	13	ECU	13	8	ECU (56)
630	13	ECU	13	9	ECU (CA3C)
630	13	ECU	13	18	ECU (CC)
630	13	ECU	13	21	ECU (6C)
630	13	ECU	13	22	ECU (63C)
630	13	ECU	13	25	VIN Mismatch
630	13	ECU	13	26	Valve Configuration Mismatch
639	2	J1939	11	3	J1939 Engine (EEC1) Electronic Engine Controller Loss of Communication or Time Out
639	2	J1939	11	2	J1939 Electronic Retarder Timeout or Invalid Signal (ERC1)
639	2	J1939	11	4	J1939 Electronic Engine Controller 2 Timeout or Invalid Message (EEC2)
639	2	J1939	11	7	Timeout or Invalid Data on ETC7 or VP15 Transmission Message for HSA
639	2	J1939	11	8	Timeout or Invalid Data on XBR Message

APPENDIX: J1939 SPN and FMI Codes and their Bendix Blink Code Equivalents

SPN (J1939)	FMI (J1939)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
639	2	J1939	11	10	J1939 Transmission (ETC1) Electronic Transmission Controller, loss of communication message or time out
639	2	J1939	11	11	AUXIO CAN Message Timeout
639	2	J1939	11	12	J1939 Hill Start Aid Switch Signal Not Available
639	2	J1939	11	15	J1939 Engine (EEC3) Electronic Transmission Controller loss of communications or time out
639	2	J1939	11	16	J1939 Transmission (ETC2) Electronic Transmission Controller loss of communications or time out
639	2	J1939	11	3	J1939 Engine (EEC1) Electronic Engine Controller loss of communications between EC-80 ECU and other devices
639	2	J1939	11	2	J1939 Retarder (ERC1) Electronic Retarder Controller loss of communications or time out
639	2	J1939	11	4	J1939 Engine (EEC2) Electronic Engine Controller loss of communications or time out
639	2	J1939	11	10	J1939 Transmission Loss of Communications, ETC1 message
639	2	J1939	11	15	J1939 Engine Loss of Communications, EEC2 message
639	2	J1939	11	16	J1939 Transmission Loss of Communications, ETC2 message
639	12	J1939	11	1	J1939 Serial Link Loss of Communication Between EC-80 ECU and Other Devices
789	1	Wheel Speed Sensor	2	1	SA Left WSS Excessive Air Gap
789	2	Wheel Speed Sensor	2	3	SA Left WSS Open or Shorted
789	7	Wheel Speed Sensor	2	5	SA Left WSS Wheel End
789	8	Wheel Speed Sensor	2	6	SA Left WSS Erratic Sensor Signal
789	9	Wheel Speed Sensor	2	2	SA Left WSS Output Low @ Drive-Off
789	10	Wheel Speed Sensor	2	4	SA Left WSS Loss of Sensor Signal
789	13	Wheel Speed Sensor	2	7	SA Left WSS Tire Size Calibration
790	1	Wheel Speed Sensor	3	1	SA Right WSS Excessive Air Gap
790	2	Wheel Speed Sensor	3	3	SA Right WSS Open or Shorted
790	7	Wheel Speed Sensor	3	5	SA Right WSS Wheel End
790	8	Wheel Speed Sensor	3	6	SA Right WSS Erratic Sensor Signal
790	9	Wheel Speed Sensor	3	2	SA Right WSS Output Low @ Drive-Off
790	10	Wheel Speed Sensor	3	4	SA Right WSS Loss of Sensor Signal
790	13	Wheel Speed Sensor	3	7	SA Right WSS Tire Size Calibration
791	1	Wheel Speed Sensor	4	1	DA Left WSS Excessive Air Gap
791	2	Wheel Speed Sensor	4	3	DA Left WSS Open or Shorted
791	7	Wheel Speed Sensor	4	5	DA Left WSS Wheel End
791	8	Wheel Speed Sensor	4	6	DA Left WSS Erratic Sensor Signal
791	9	Wheel Speed Sensor	4	2	DA Left WSS Output Low @ Drive-Off
791	10	Wheel Speed Sensor	4	4	DA Left WSS Loss of Sensor Signal
791	13	Wheel Speed Sensor	4	7	DA Left WSS Tire Size Calibration
792	1	Wheel Speed Sensor	5	1	DA Right WSS Excessive Air Gap
792	2	Wheel Speed Sensor	5	3	DA Right WSS Open or Shorted
792	7	Wheel Speed Sensor	5	5	DA Right WSS Wheel End
792	8	Wheel Speed Sensor	5	6	DA Right WSS Erratic Sensor Signal
792	9	Wheel Speed Sensor	5	2	DA Right WSS Output Low @ Drive-Off
792	10	Wheel Speed Sensor	5	4	DA Right WSS Loss of Sensor Signal
792	13	Wheel Speed Sensor	5	7	DA Right WSS Tire Size Calibration
793	1	Wheel Speed Sensor	14	1	AA Left WSS Excessive Air Gap

APPENDIX: J1939 SPN and FMI Codes and their Bendix Blink Code Equivalents

SPN (J1939)	FMI (J1939)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
793	2	Wheel Speed Sensor	14	3	AA Left WSS Open or Shorted
793	7	Wheel Speed Sensor	14	5	AA Left WSS Wheel End
793	8	Wheel Speed Sensor	14	6	AA Left WSS Erratic Sensor Signal
793	9	Wheel Speed Sensor	14	2	AA Left WSS Output Low @ Drive-Off
793	10	Wheel Speed Sensor	14	4	AA Left WSS Loss of Sensor Signal
794	1	Wheel Speed Sensor	15	1	AA Right WSS Excessive Air Gap
794	2	Wheel Speed Sensor	15	3	AA Right WSS Open or Shorted
794	7	Wheel Speed Sensor	15	5	AA Right WSS Wheel End
794	8	Wheel Speed Sensor	15	6	AA Right WSS Erratic Sensor Signal
794	10	Wheel Speed Sensor	15	4	AA Right WSS Loss of Sensor Signal
794	14	Wheel Speed Sensor	15	2	AA Right WSS Output Low @ Drive-Off
795	5	Pressure Modulator Valve	7	7	SA Left PMV CMN Open Circuit
795	13	Pressure Modulator Valve	7	8	SA Left PMV Configuration Error
796	5	Pressure Modulator Valve	8	7	SA Right PMV CMN Open Circuit
796	13	Pressure Modulator Valve	8	8	SA Right PMV Configuration Error
797	5	Pressure Modulator Valve	9	7	DA Left PMV CMN Open Circuit
797	13	Pressure Modulator Valve	9	8	DA Left PMV Configuration Error
798	5	Pressure Modulator Valve	10	7	DA Right PMV CMN Open Circuit
798	13	Pressure Modulator Valve	10	8	DA Right PMV Configuration Error
799	5	Pressure Modulator Valve	16	7	AA Left PMV CMN Open Circuit
799	13	Pressure Modulator Valve	16	8	AA Left PMV Configuration Error
800	5	Pressure Modulator Valve	17	7	AA Right PMV CMN Open Circuit
800	13	Pressure Modulator Valve	17	8	AA Right PMV Configuration Error
801	2	Miscellaneous	12	4	Retarder Relay Open Circuit or Shorted to Ground
801	3	Miscellaneous	12	5	Retarder Relay Circuit Shorted to Voltage
802	3	Miscellaneous	12	8	PMV/TCV/Diff Lock Common Shorted to Voltage
802	4	Miscellaneous	12	7	PMV/TCV/Diff Lock Common Shorted to Ground
802	12	ECU	13	11	ECU (F1A)
802	12	ECU	13	12	ECU (F14)
805	14	Miscellaneous	12	9	ATC Disabled to Prevent Brake Fade
806	3	TCV	18	2	TCV Solenoid Shorted to Voltage
806	4	TCV	18	1	TCV Solenoid Shorted to Ground
806	5	TCV	18	3	TCV Solenoid Open Circuit
806	13	TCV	18	4	TCV Configuration Error
810	7	Miscellaneous	12	11	Wheel Speed Sensors Reversed on an Axle
811	2	Miscellaneous	12	6	ABS Warning Lamp Circuit
815	13	Wheel Speed Sensor	14	10	Additional Axle WSS Configuration Error
932	3	Pressure Modulator Valve	7	5	SA Left PMV HLD Solenoid Shorted to Voltage
932	4	Pressure Modulator Valve	7	4	SA Left PMV HLD Solenoid Shorted to Ground
932	5	Pressure Modulator Valve	7	6	SA Left PMV HLD Solenoid Open Circuit
933	3	Pressure Modulator Valve	8	5	SA Right PMV HLD Solenoid Shorted to Voltage
933	4	Pressure Modulator Valve	8	4	SA Right PMV HLD Solenoid Shorted to Ground
933	5	Pressure Modulator Valve	8	6	SA Right PMV HLD Solenoid Open Circuit

APPENDIX: J1939 SPN and FMI Codes and their Bendix Blink Code Equivalents

SPN (J1939)	FMI (J1939)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
934	3	Pressure Modulator Valve	9	5	DA Left PMV HLD Solenoid Shorted to Voltage
934	4	Pressure Modulator Valve	9	4	DA Left PMV HLD Solenoid Shorted to Ground
934	5	Pressure Modulator Valve	9	6	DA Left PMV HLD Solenoid Open Circuit
935	3	Pressure Modulator Valve	10	5	DA Right PMV HLD Solenoid Shorted to Voltage
935	4	Pressure Modulator Valve	10	4	DA Right PMV HLD Solenoid Shorted to Ground
935	5	Pressure Modulator Valve	10	6	DA Right PMV HLD Solenoid Open Circuit
936	3	Pressure Modulator Valve	16	5	AA Left PMV HLD Solenoid Shorted to Voltage
936	4	Pressure Modulator Valve	16	4	AA Left PMV HLD Solenoid Shorted to Ground
936	5	Pressure Modulator Valve	16	6	AA Left PMV HLD Solenoid Open Circuit
937	3	Pressure Modulator Valve	17	5	AA Right PMV HLD Solenoid Shorted to Voltage
937	4	Pressure Modulator Valve	17	4	AA Right PMV HLD Solenoid Shorted to Ground
937	5	Pressure Modulator Valve	17	6	AA Right PMV HLD Solenoid Open Circuit
938	3	Pressure Modulator Valve	7	2	SA Left PMV REL Solenoid Shorted to Voltage
938	4	Pressure Modulator Valve	7	1	SA Left PMV REL Solenoid Shorted to Ground
938	5	Pressure Modulator Valve	7	3	SA Left PMV REL Solenoid Open Circuit
939	3	Pressure Modulator Valve	8	2	SA Right PMV REL Solenoid Shorted to Voltage
939	4	Pressure Modulator Valve	8	1	SA Right PMV REL Solenoid Shorted to Ground
939	5	Pressure Modulator Valve	8	3	SA Right PMV REL Solenoid Open Circuit
940	3	Pressure Modulator Valve	9	2	DA Left PMV REL Solenoid Shorted to Voltage
940	4	Pressure Modulator Valve	9	1	DA Left PMV REL Solenoid Shorted to Ground
940	5	Pressure Modulator Valve	9	3	DA Left PMV REL Solenoid Open Circuit
941	3	Pressure Modulator Valve	10	2	DA Right PMV REL Solenoid Shorted to Voltage
941	4	Pressure Modulator Valve	10	1	DA Right PMV REL Solenoid Shorted to Ground
941	5	Pressure Modulator Valve	10	3	DA Right PMV REL Solenoid Open Circuit
942	3	Pressure Modulator Valve	16	2	AA Left PMV REL Solenoid Shorted to Voltage
942	4	Pressure Modulator Valve	16	1	AA Left PMV REL Solenoid Shorted to Ground
942	5	Pressure Modulator Valve	16	3	AA Left PMV REL Solenoid Open Circuit
943	3	Pressure Modulator Valve	17	2	AA Right PMV REL Solenoid Shorted to Voltage
943	4	Pressure Modulator Valve	17	1	AA Right PMV REL Solenoid Shorted to Ground
943	5	Pressure Modulator Valve	17	3	AA Right PMV REL Solenoid Open Circuit
1045	2	Miscellaneous	12	2	Stop Lamp Switch Defective
1045	7	Miscellaneous	12	1	Stop Lamp Switch Not Detected
2622	2	Miscellaneous	12	24	HSA Lamp Open Circuit or Shorted to Ground
2622	3	Miscellaneous	12	26	HSA Valve Solenoid Shorted to Voltage
2622	3	Miscellaneous	12	31	HSA Lamp Shorted to Voltage
2622	4	Miscellaneous	12	25	HSA Valve Solenoid Shorted to Ground
2622	5	Miscellaneous	12	33	HSA Valve Solenoid Open Circuit

